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TRILOBITES OF THE ORDOVICIAN TABLE HEAD FORMATION, WESTERN NEWFOUNDLAND

By H. B. Whittington

With Sixty-eight Plates

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No. 4—*Trilobites of the Ordovician Table Head Formation, western Newfoundland*

By H. B. Whittington

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INTRODUCTION AND ACKNOWLEDGEMENTS

A brief history of work on the Table Head Formation, and an account of the stratigraphy, have recently been given (Whittington and Kindle, 1963). These pages describe the trilobites and discuss the composition of the fauna, its age and relations to other faunas in time and space. The formation is 1100 feet thick at its type section at Table Point (Text-fig. 1). The lower 800 feet is of light gray limestone with some dolomite in the lower part. The middle part of the formation, 270 feet thick, is darker in colour and interbedded with dark shale. The upper 30 feet is black shale containing graptolites. E. Billings, the first investigator, described 27 species of trilobites now considered valid, coming mostly from the middle part. P. E. Raymond described seven additional species here considered valid. Almost twice this total, 66 species, are recognized here, the vast majority from the middle part. The importance of this fauna lies not only in its richness, but in its excellence of preservation

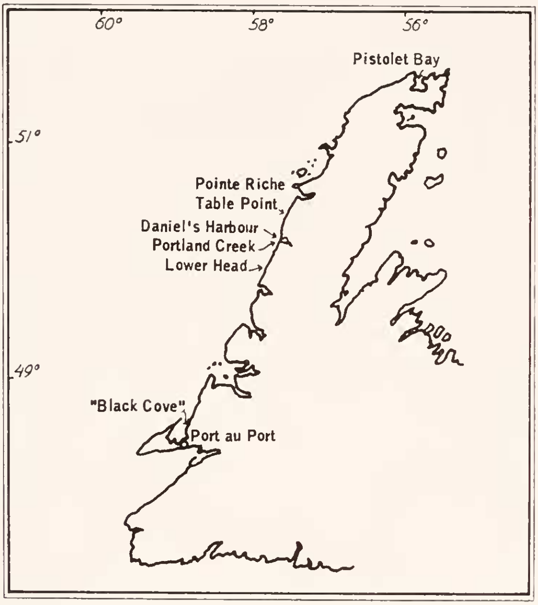

FIG. 1. Map showing localities in western Newfoundland referred to in the text.

and in its age. Varied, well-preserved Lower Ordovician faunas have been described in recent years (Ross, 1951; Hintze, 1953), as have middle to late Middle Ordovician faunas (Whittington, 1959). The Table Head fauna is early Middle Ordovician in age, and quite different from the slightly younger Chazy trilobites. The recently-described fauna of 45 species from a boulder at Lower Head, 30 miles south of Table Point (Text-fig. 1), is of about the same age but has only one species in common. Together, these faunas afford an extraordinary glimpse of the trilobites occupying a variety of ecological niches in Whiterock time. The approximately contemporaneous European faunas, in Llanvirn rocks of Bohemia and Britain, are of comparable richness and contain genera belonging to some of the same families, and to several different families. No species and very few genera are in common, a difference here ascribed to a difference in province. The photographs attest to the remarkable preservation, though complete exoskeletons are rare. The great amount of new morphological information has helped to clarify the systematic position of certain old species.

I am deeply indebted to Cecil H. Kindle for urging me to join him in work in western Newfoundland, and for placing at my disposal his earlier collections. The collections we made together in 1958 and 1961, with the enthusiastic assistance of Mrs. Whittington and Miss Mary Anne Kindle, form the basis of this work. Essential was the opportunity to study earlier material, including types. Drs. T. E. Bolton and D. J. McLaren kindly made this possible at the Geological Survey of Canada, and Prof. Karl M. Waagé at the Peabody Museum, Yale University. Field work in western Newfoundland in 1958 and 1961 was carried out by Kindle and me under National Science Foundation grant G-4189. The cost of publication of the plates, part of the costs of binding, and of technical assistance to me, have been borne by National Science Foundation grant G-19082. The skillful help of Eleanor A. Ormiston in preparing enlargements from my negatives and in mounting the plates is gratefully acknowledged. Mr. N. Strekalovsky prepared Text-figures 1-7.

LOCALITIES AND LISTS OF SPECIES

An account of the stratigraphy of the Table Head Formation (Whittington and Kindle, 1963) reviews previous work, describes in more detail the localities mentioned below, and includes lists of trilobites, graptolites and other fossils. The localities given in the present systematic section and plate explanations are referred to by the paragraph headings used below and are shown on Text-figure 1. The lists of trilobite species given previously are emended and amplified. As an indication of relative abundance, counts are given of cephala or cranidia (c) and pygidia (p), obtained from the type section and at Table Cove. These figures are not unbiased, since only better-preserved specimens were brought back to the laboratory. The species are listed in the same systematic order as given in the Table of Contents.

LOWER TABLE HEAD FORMATION

Type section. Exposed on the north side of Table Point (Text-fig. 1), 810 feet of limestone with some dolomites (Whittington and Kindle, 1963, pp. 747-9, fig. 1). Stratigraphical ranges of species are corrected where they differ from those given in Whittington and Kindle, 1963, figure 2:

	C	P
Stegnopsis solitarius n. gen., n. sp. (recorded as "aff. Isoteloides sp.")	0	8
Nileus affinis (now identified in the middle Table Head formation)	5	2
Eorobergia grandis n. sp.	0	6
Uromystrum validum	23	23
Acidiphorus spinifer	23	5
Illaenus fraternus	24	12
Illaenus marginalis	37	29
Illaenus alveatus	17	0
Illaenus sp. ind. 1 — from bed 8 at 280 feet above base	1	0
Pseudomera barrandei	8	18
Ectenonotus westoni	0	9
Xystocrania perforator (now recorded from middle Table Head Formation)	1	0
Xystocrania cf. *glaucus* — from bed 8 at 350 feet above base	1	0
Calyptaulax incepta n. sp. — from bed 8 at 350 and 379 feet above base	1	1

Pointe Riche. On the shore about one-half mile north of Pointe Riche lighthouse (Whittington and Kindle, 1963, p. 752) the following trilobites were found:

Stegnopsis solitarius n. gen., n. sp.
Nileus affinis
Eorobergia grandis
Uromystrum validum
Acidiphorus spinifer
Illaenus marginalis
Pseudomera barrandei
Ectenonotus westoni
Kawina sp. ind.

Middle Table Head Formation

Type section. Exposed on the south side of Table Point, 270 feet of limestone (Whittington and Kindle, 1963, pp. 749-750, fig. 1). The list of species (and their stratigraphical range) given in Whittington and Kindle, 1963, figure 3, is emended and amplified as follows:

	C	P
Geragnostus longicollis	4	3
Geragnostus fabius — 185 to 215 feet above base	14	8
Galbagnostus galba	5	2
Harpides atlanticus — 17 to 265 feet above base	3	0
Lonchodomas normalis	35	32
Lonchodomas clavulus n. sp. — 17 to 50 feet above base	12	7
*° *Ampyx laeviusculus*	14	11
Ampyxoides semicostatus	21	27
° *Endymionia schucherti*	19	10
Shumardia sagittula n. sp. — 130 to 265 feet above base	2	0
Leioshumardia minima n. gen., n. sp. — 17 to 190 feet above base	3	0
Triarthrus fischeri	23	1
* *Hypermecaspis bulmani* — exact horizon unknown	2	1
* *Phascolops?* sp. ind. — 185 feet above base	1	0
Ischyrophyma tumida n. sp. — 50 feet above base	2	0
*° Cranidium gen. ind. 1 — 90 feet above base	1	0
Stegnopsis huttoni	9	14
Niobe quadraticaudata	14	13
Niobe morrisi — 90 to 265 feet above base	6	19
Nileus affinis — 17 to 265 feet above base (recorded previously in part as *N. scrutator*)	20	16
° *Nileus scrutator* — 90 and 215 feet above base	5	5
Nileus macrops	12	11
Peraspis lineolata — 130 to 190 feet above base	6	19
° *Nileus? lacunosa* — 190 feet above base	2	1
Telephina americana	33	3
Goniophrys breviceps ? — 17 feet above base	3	0
*° *Remopleurides* sp. ind. — 190 feet above base	4	0
Robergia schlotheimi	7	5
Blosyropsis billingsi n. gen., n. sp.	6	1
Illaenus consimilis	34	17
Illaenus gelasinus n. sp. — 90 feet above base	6	6
Raymondaspis reticulatus n. sp.	28	17
*° *Raymondaspis turgidus* n. sp. — 190 feet above base	3	8
Pseudomera barrandei	8	12
Ceraurinella polydorus	2	0
*° *Xystocrania perforator* — exact horizon unknown	1	0
* *Heliomera sol* — exact horizon unknown	1	0

*°*Heliomera* (*Heliomeroides*) sp. ind.. — recorded previously 17 feet above base as ''*H. sol*''	1	0
Miracybele mira	6	4
*°Cybelinid cranidium — 90 feet above base	1	0
Cybelinid pygidium — 265 feet above base	0	1

* Not found at Table Cove.
° Not found in isolated limestone.

Table Cove. The fossils came almost entirely from 30 to 40 feet of limestones exposed on the foreshore on the south side of Table Cove, which is 4000 feet south of Table Point (Whittington and Kindle, 1963, p. 752, fig. 1). A few specimens are from the highest beds exposed. The complete list of trilobites obtained is as follows:

	C	P
Geragnostus longicollis	9	12
Geragnostus fabius	6	6
Galbagnostus galba	13	23
Harpides atlanticus	52	0
**Selenoharpes singularis* n. sp.	13	0
Lonchodomas normalis	18	4
Lonchodomas clavulus n. sp.	8	1
Ampyxoides semicostatus	15	7
Endymionia schucherti	8	1
Shumardia sagittula n. sp.	12	0
Leioshumardia minima n. gen., n. sp.	2	0
Triarthrus fischeri	38	1
Ischyrophyma tumida n. sp.	28	0
**Ischyrophyma?* sp. ind.	2	0
**Ischyrotoma* sp. ind.	1	0
Stegnopsis huttoni	13	7
Niobe quadraticaudata	12	22
Niobe morrisi	2	2
Nileus affinis	15	4
Nileus scrutator	0	1
Nileus macrops	7	0
Peraspis lineolata	3	2
Nileus? lacunosa n. sp.	2	0
Telephina americana	36	1
Goniophrys breviceps?	6	0
**Carolinites* sp. ind. 2	1	0
**Remopleurides pilulus* n. sp.	12	0
Robergia schlotheimi	3	3
Blosyropsis billingsi n. gen., n. sp.	9	3
Illaenus consimilis	41	4
Illaenus gelasinus n. sp.	3	0
**Illaenus* sp. ind. 3	0	2

Raymondaspis reticulatus	48	31
Pseudomera barrandei	14	22
Ceraurinella polydorus	19	6
**Cydonocephalus* sp. ind.	1	0
aff. *Calymenidius* sp. ind.	2	0
Miracybele mira	23	9
Cybelinid pygidium	0	2

* Not in middle Table Head Formation at type section, but may be present in isolated limestone.

Isolated Limestone. A small, isolated hill of limestone at the landward side of the beach at Table Cove (Whittington and Kindle, 1963, p. 752, fig. 1) yielded the following trilobites:

Geragnostus longicollis
Geragnostus fabius
Galbagnostus galba
Harpides atlanticus
Lonchodomas normalis
Lonchodomas clavulus n. sp.
Ampyxoides semicostatus
Shumardia sagittula n. sp.
Leioshumardia minima n. gen., n. sp.
Triarthrus fischeri
Phaseolops ? sp. ind.
Ischyrophyma tumida n. sp.
Ischyrophyma ? sp. ind.
Stegnopsis huttoni
Niobe quadraticaudata
Niobe morrisi
Nileus affinis
Nileus macrops
Peraspis lineolata
Telephina americana
Goniophrys breviceps ?
Robergia schlotheimi
Blosyropsis billingsi n. gen., n. sp.
Illaenus consimilis
Illaenus gelasinus n. sp.
**Illaenus* sp. ind. 2
Raymondaspis reticulatus
Ceraurinella polydorus
Heliomera sol
Miracybele mira
Cybelinid pygidium
*Cranidium gen. ind. 2

* Not found in middle Table Head Formation at type section.

Black Cove. This locality, on the shore about one-half mile northeast of The Gravels at Port au Port peninsula (Whittington and Kindle, 1963, pp. 752-753), yielded trilobites from the thin limestones of bed 4, and the emended list is:

Geragnostus fabius
Ampyxoides semicostatus
Anisonotella glacialis
Endymionia sp.
Triarthrus fischeri
Stegnopsis huttoni
Niobe quadraticaudata
Niobe morrisi
Nileid gen. ind.
Peraspis lineolata
Telephina americana
Carolinites sp. ind. 1
Robergia schlotheimi

Table Head Boulders in Cow Head Group Conglomerates

Portland Creek. Boulders in conglomerates of the Cow Head Group exposed on the shore at the mouth of the creek and for some distance to the north (Whittington and Kindle, 1963, p. 753) yielded the trilobites listed below. James Richardson's notebook of July, 1861, shows that he collected from these boulders, approximately 300 yards north of the mouth of Portland Creek.

Geragnostus fabius
Lonchodomas normalis
Peraspis lineolata
Nileus ? lacunosa n. sp.
Nileus cf. *scrutator*
Triarthrus fischeri
Illaenus alveatus
Robergia schlotheimi
Calyptaulax incepta n. sp.
Pseudomera barrandei
Miracybele mira

Billings (1861-5) recorded some of these species and in addition *Anisonotella glacialis* and *Ceraurinella polydorus. Illaenus alveatus* is the only lower Table Head Formation trilobite from these boulders, all others being of middle Table Head age.

Daniel's Harbour. Boulders in conglomerates of the Cow Head Group at this locality yielded trilobites (Whittington and Kindle, 1963, pp. 753-754). At the time that the earlier paper was written it was thought that this locality was probably that described by Billings (1865, pp. 272-273, etc.) as being "four miles northeast from Portland Creek." Subsequent examination of James Richardson's notebook shows that he did indeed collect in July, 1861, from "Daniel's Cove." The emended list from these boulders is as follows:

Geragnostus fabius
Ampyxoides semicostatus
Anisonotella glacialis
Endymionia schucherti
Shumardia sagittula n. sp.
Triarthrus fischeri
? Stegnopsis huttoni
Niobe quadraticaudata
Niobe morrisi
Nileus affinis ?
Nileus macrops
Nileus? lacunosa n. sp.
Peraspis lineolata
Telephina americana
Robergia schlotheimi
Blosyropsis billingsi n. gen., n. sp.
Illaenus gelasinus n. sp.
Raymondaspis reticulatus

In addition, Billings (1861-5) recorded from this locality *Galbagnostus galba, Harpides atlanticus, Lonchodomas normalis, Illaenus fraternus*, and *Heliomera sol.*

TABLE HEAD TRILOBITE FAUNA

NUMBERS AND RELATIVE ABUNDANCE OF SPECIES

The trilobites of the lower part of the Table Head Formation are moderately abundant and varied, those of the middle part exceptionally rich, as shown by the following table:

	Families	Genera	Species
Lower Table Head	8	11	14
Middle Table Head	21	38	55
In common to above	6	5	3
Faunal resemblance	75%	45%	21%

The index of faunal resemblance is the percentage in the smaller sample of the taxa in common (Simpson, 1960). These indices suggest that no important break in time occurs between the lower and middle parts of the formation. The different types of limestones that characterise the two parts reflect differences in conditions of deposition and preservation, and these differences may account for the disparity in numbers and kinds of trilobites in them. The lower Table Head Formation (Schuchert and Dunbar, 1934, p. 64; Whittington and Kindle, 1963, pp. 747-749, figure 2) is composed of gray limestone and dolomites in the lower one-fifth, the remainder of gray, rubbly limestones, the trilobites coming mainly from thin layers of lime-sand in this upper portion. In contrast, the middle Table Head limestones (Schuchert and Dunbar, 1934, pp. 63-64; Whittington and Kindle, 1963, pp. 749-750, fig. 3) are dominantly dark-gray in colour, muddy, and interbedded with black shale in increasing amounts upward. This distinction is a generalised one, and lime-sands from the upper part of the lower Table Head, the middle Table Head 90 feet above the base of the type section, at Table Cove and the isolated limestone, are similar in colour and grain size.

Stratigraphical ranges of species within the type section of the formation given previously (Whittington and Kindle, 1963, figs. 2, 3) are here emended and others added. These ranges are least reliable in the lower 90 feet of the middle part of the formation, in which collecting was least intensive. As a measure of relative abundance of species, total numbers are given of specimens collected from the type section and at Table Cove. In the limited and sporadically distributed fauna of the lower Table Head no one species dominates the assemblage. The same is true of the far more diverse fauna of the middle Table Head at the type section — no one species forms more than 10 per cent of the total numbers, and of nineteen species each constitutes between 2 and 10 per cent of the total. The collection at Table Cove is from a limited thickness of middle Table Head strata. Six rare species and two more abundant species at Table Cove have not yet been found in the type section, while eight rare and two more abundant species of the type section have not been recovered at Table Cove. At this latter locality no one species is more than 12 per cent of the total, and each of 21 species constitutes between 2 and 12 per cent of the total. Only eleven of the commonest species at Table Cove are abundant at the type section, and the order of relative abundance is different.

These differences are between exposures less than one mile apart. Those of relative abundance may reflect the limited thickness from which the Table Cove sample came, the type section sample being an average for the entire thickness. The middle Table Head Formation shows evidence of contemporaneous disturbance, so that particular beds may be present in one section and absent in a nearby one. This may help to account for the presence or absence of particular species at these two localities.

Composition, Relation to Older and Younger Faunas

All the trilobite species of the Table Head Formation are unique to it, except *Nileus affinis,* known from the boulder at Lower Head and the Island of Orleans, near Quebec City. Fourteen new species are named here, and an additional 20 are indeterminate. Of the eight new genera proposed, six are based on species unique to the formation. The remaining two, *Xystocrania* and *Miracybele,* include species from Nevada, and *Miracybele* is probably also represented in Norway. The fauna of the formation (especially that of the middle part) includes early Ordovician elements, some making their last appearance, and new genera belonging to families which characterise younger rocks. The genera *Geragnostus, Harpides, Shumardia, Triarthrus, Hypermecaspis, Niobe, Nileus,* and *Pharostomina* (a close relative of *Calymenidius*) are known from the early Ordovician Tremadoc rocks of western Europe (Sdzuy, 1955; Henningsmoen, 1959), and many occur in these rocks in Argentina (Harrington and Leanza, 1957, pp. 24-29). In Canadian or Arenig rocks *Selenoharpes, Ampyx, Ischyrotoma, Carolinites, Goniophrys, Raymondaspis* and *Illaenus* are known. Genera making their first appearance in North America or elsewhere, and characteristic of younger Ordovician strata, are: *Lonchodomas, Phaseolops*? (a proetid), *Telephina, Remopleurides, Robergia, Bronteopsis, Ceraurinella, Heliomera* and *Calyptaulax.* The latter elements give the fauna a post-Canadian aspect but do not include many typical Chazyan and younger genera (cf. Whittington and Kindle, 1963, p. 756).

Correlation with Other Areas

The most suitable index of faunal resemblance for the present purpose appears to be method two of Simpson (1960), the percentage of taxa in common between two localities. In the following table a standard is provided by indices for the middle

Table Head Formation at two localities less than one mile apart, and by those for the lower and middle parts indicative of close relation but with some difference in age.

Faunal resemblance between:	Based on	
	genera	species
middle Table Head, type section/Table Cove	80	79
lower Table Head/middle Table Head	45	21
lower Table Head/Lower Head	64	7
middle Table Head/Lower Head	50	2
Table Head/Mystic Conglomerate, Quebec	76	
Lower Head/Mystic Conglomerate, Quebec	59	
Table Head/Antelope Valley Lst., Nevada	63	
Table Head/Chazy Group, New York	20	
Table Head/Tumbez Formation, Tennessee	20	
Table Head/Effna Formation, Virginia	25	
Table Head/Athens Shale, Tennessee	31	
Table Head/Kundan Stage, Sweden	23	
Table Head/Kundan Stage, East Baltic	21	
Table Head/Llanvirn Stage, Britain and Bohemia — less than	10	

Notes in explanation of this table follow, together with comments on other faunas.

Lower Head. The fauna of the boulder at this locality (Whittington, 1963), thirty miles south of Table Point, is like that of the Table Head, and most like that of the lower part. The strong similarity between, but not identity of, species of *Geragnostus, Selenoharpes, Phaseolops, Ischyrotoma, Ischyrophyma, Remopleurides, Aeidiphorus, Illaenus, Cydonocephalus, Kawina, Heliomera, Pseudomera* and *Ectenonotus* in the two deposits is a further expression of the close relationship.

The greater variety of the Lower Head fauna, compared to that of the lower Table Head, may be attributed to differences in environment of deposition. The Lower Head fauna includes *Isocolus, Glaphurus, Ceratocephala* and *Apatolichas.* Species of these genera, or of genera belonging to the same families, are absent from both lower and middle Table Head rocks. The middle Table Head fauna is more varied than the Lower Head, and contains raphiophorids, endymioniids, shumardids, olenids, asaphids, telephinids, komaspidids, calymenids, encrinurids and dalmanitids, none of which families is present in the Lower Head boulder. These and other differences between the faunas (e.g. different scutelluid genera in each, some cheirurid genera only in Table Head) seem more likely to reflect differences in environment of deposition than to imply any great difference in age.

Lévis Shale, Québec. The highest part of these shales, zone D, includes the Shumardia Limestone and overlying shales which are of the same age as the high middle and upper parts of the Table Head Formation (Whittington and Kindle, 1963, pp. 755-756, fig. 4). As shown below, the species of *Shumardia, Endymionia* and *Triarthrus?* from Quebec are different from the Table Head species. *Endymionia meeki* and *Raymondaspis angelini,* from boulders in limestone conglomerate in the Lévis Shale, are like but not the same as Table Head species of the same genera.

Mystic Conglomerate, Québec. Brachiopods from boulders in this conglomerate have been described by Cooper (1956, p. 31, for list) and certain trilobites by Billings (1865), Raymond (1925), Ulrich (1930) and Whittington (1948, 1961). I have not studied the trilobite fauna in detail, but examination of collections in the U. S. National Museum, Geological Survey of Canada and Museum of Comparative Zoology suggests that the following are present (cf. Raymond, 1925, p. 170, who lists many of these species from a single boulder, together with *Goniophrys breviceps* [Billings, 1865]):

Geragnostus sp.
Ischyrophyma sp.
Ptyocephalus curiosus (Billings, 1865)
Nileus sp.
Telephina mysticensis (Ulrich, 1930)
Remopleurides affinis Billings, 1865
Acidiphorus scorpionis Raymond, 1925
Bathyurellus expansus Billings, 1865
Illaenus sp. (of *tumidifrons* Billings, 1865, type)
Illaenus simulator Billings, 1865
Illaenus incertus Billings, 1865
Raymondaspis marginata (Raymond, 1925)
Ectenonotus westoni (Billings, 1865)
Pliomerids — *bilirata* Raymond, 1925
  — *convexus* Billings, 1865
Kawina billingsi Raymond, 1905
Kawina sp.
Cydonocephalus spp.
Xystocrania glaucus (Billings, 1865)
Apatolichas sp.

The strong similarity between this fauna and that from Table Head is evident. The species I have studied are like those from Newfoundland, but they do not seem to be identical.

Nevada. Collections from the Antelope Valley Limestone (Merriam, 1963, pp. 23-25) in the U.S. National Museum, my own collections, and those made by Kay (1962, table 2, pp. 1424-1425) suggest that at least 16 genera of trilobites are present in this formation. No species appears to be in common with the Table Head, but ten genera are, giving a high index of faunal resemblance. It is probable that these formations are of approximately the same age (cf. Whittington and Kindle, 1963, pp. 754-755).

Chazy Group, New York and Québec. Trilobites from these rocks (Raymond, 1905; 1910) are being studied by Frederick C. Shaw, Harvard University. His work shows that species of about 40 genera are present, which do not include any of the Lower Ordovician (Tremadoc and Canadian) genera mentioned above. In common with the Table Head are the genera *Lonchodomas, Remopleurides, Uromystrum, Ceraurinella, Kawina, Heliomera, Calyptaulax,* and possibly the asaphid *Stegnopsis* n. gen. No species is common to Chazy and Table Head strata, and the index of faunal resemblance based on genera is 20 per cent. The Chazy trilobites have a geologically younger aspect than those of the Table Head, and include a number of genera found only in Chazyan and younger rocks, such as *Dolichoharpes, Dimeropyge, Otarion, Sphaerocoryphe, Encrinuroides* and *Cybeloides.* This evidence supports the view (Cooper, 1956) that the Chazy rocks are younger than the Table Head (cf. Whittington and Kindle, 1963, p. 756, fig. 4).

Southern Appalachians. Of the same age as part of the Chazy Group is the Tumbez Formation of southern Virginia and adjacent Tennessee (Cooper, 1956, chart). Where it is exposed near Bluff City, Tennessee, this granular limestone yields a considerable trilobite fauna (Raymond, 1925, p. 171) including the type species of *Eorobergia.* The fauna shows little resemblance to that of the Table Head. Considerably younger are the shales and silty limestones of the Athens of Tennessee and the granular Effna limestone of Virginia (see lists in Raymond, 1925, pp. 173, 174; Cooper, 1953, table 1), for they belong to the early part of the Porterfield Stage (Cooper, 1956, chart 1). Such resemblance as they show to the Table Head is due to the presence of the long-ranging genera *Lonchodomas, Ampyx, Robergia, Raymondaspis* and *Calyptaulax,* as well as *Telephina* in the Athens and a species of *Nileus* in the Effna.

Scandinavia and the East Baltic. Strata of the Kundan Stage (Jaanusson, 1960, tables 3, 9) in Sweden, Norway, Estonia and the Leningrad district are latest Arenig and early Llanvirn in age, approximately the age of the Table Head Formation (Whittington and Kindle, 1963, p. 757, fig. 4). Species of *Ampyx, Niobe, Nileus, Illaenus, Raymondaspis, Bronteopsis, Ceraurinella?* and *Miracybele* n. gen. that have been obtained from them are like those in the Table Head, but other genera of asaphids, cheirurids, pliomerids and encrinurids in these strata are not represented in Newfoundland. The index for the beds in Sweden is based on Bohlin's list (1949, pp. 566-567), that for the East Baltic on Schmidt's (1907, pp. 90-98). These indices are similar to that of 20 per cent for Table Head and early Arenig trilobites of Sweden (Tjernvik, 1956).

Central Europe. Beds of Llanvirn age in Britain and Bohemia contain a large trilobite fauna, considered to belong in a quite different province to the Table Head (see below). The low index expresses the lack of resemblance.

South America. Bulman (1931) described graptolites and a few trilobites from beds of Llanvirn age of Korpa, Bolivia, a locality north of Lake Titicaca and near the border with Peru. The trilobites included *Triarthrus* aff. *fischeri* and *Saukia?* sp., the latter now *Hypermecaspis bulmani* Harrington and Leanza, 1957 (pp. 121-123). Fragments from the Table Head very like *H. bulmani* are described below, and *T. fischeri* is a common species. In addition, boulders at Daniel's Harbour (Whittington and Kindle, 1963, pp. 753-754) have yielded a species of *Glossograptus* like *G. holmi* Bulman, 1931, also present at the Korpa locality. A connection thus seems to have existed between Newfoundland and the South American geosyncline (Harrington, 1962, pp. 1781-1783, figs. 3-5). That such a connection existed in early Ordovician (Tremadoc) time has been claimed on the basis of similar or identical olenid species (Richardson, 1948; Newell, 1949; Shaw, 1950, pp. 110-111; 1951, pp. 102-103; 1956, pp. 1210-1211) in Argentina and Newfoundland. Harrington and Leanza (1957, pp. 23-37) have shown in much more detail the strong affinities in early Ordovician time between trilobite faunas of Argentina, Newfoundland, Britain and Scandinavia, and that these similarities are less evident by early Middle Ordovician time.

AGE OF THE TABLE HEAD FORMATION

The previous discussion (Whittington and Kindle, 1963, pp. 754-757) considered also evidence provided by brachiopods and graptolites. The more detailed examination of the trilobites does not seem to necessitate any change in the conclusions then drawn. Fifteen genera (one-third of the total) are relicts of older faunas, and few of them persist into younger strata. Nine genera are heralds of new faunas, widespread and at times abundant in Chazyan and younger faunas. The residue of fifteeen genera may be regarded as typical of the Table Head Formation and the Whiterock Stage:

Galbagnostus n. gen., *Ampyxoides* n. gen., *Ischyrophyma, Stegnopsis* n. gen., *Peraspis* n. gen., *Blosyropsis* n. gen., *Eorobergia, Uromystrum, Acidiphorus, Ectenonotus, Pseudomera, Xystocrania* n. gen., *Cydonocephalus, Kawina, Miracybele* n. gen.

Of the new genera, only *Xystocrania* and *Miracybele* are not unique to the Table Head, other species being known from rocks of the same age. Only *Eorobergia, Uromystrum* and probably *Kawina* are known from Marmor Stage, Chazyan, rocks. None of these Table Head genera is known in rocks of Canadian age. Thus the trilobite fauna has a post-Canadian and pre-Chazyan aspect, and appears to fall within the Whiterock Stage of G. A. Cooper and B. N. Cooper (*in* G. A. Cooper, 1956, pp. 7-8), believed to be, in European terms, approximately lower Llanvirn in age.

EVOLUTIONARY AND GEOGRAPHICAL RELATIONSHIPS

These relationships were examined in connection with the Lower Head trilobites (Whittington, 1963, pp. 16-23, fig. 2), and only additional references are given here. The Lower Head boulder is approximately the same age as the Table Head Formation but exhibits a different facies. Both faunas show a high percentage of genera new to North America, but about one-half may be descended from North American stocks. Many of the remainder belong to new families which are rapidly evolving and become important in younger faunas. No modification of the faunal provinces previously outlined is proposed. The Table Head trilobites show additional links with Baltic faunas, and a link with contemporaneous Bolivian (but not Argentinian) faunas.

Relationships. Ten genera of Table Head trilobites are present in late Cambrian and Lower Ordovician rocks of North America: *Geragnostus, Harpides, Selenoharpes, Ampyx, Shumardia* (Kobayashi, 1955, pp. 471-472), *Triarthrus* (Kobayashi, 1955, pp. 465-466, pl. 7, figs. 14-17; Henningsmoen, 1957, pp. 147, 273), *Ischyrotoma, Goniophrys, Carolinites, Calymenidius.* The remaining genera, 77 per cent of the total, are new to North America. Of these, thirteen — *Galbagnostus, Leioshumardia, Ischyrophyma, Stegnopsis, Telephina,* the four remopleuridid, two bathyurid, and two pliomerid genera — may be descended from stocks present in older North American rocks. Thus at least half the Table Head fauna may be of North American origin. Not found in North America before Table Head time are: *Hypermecaspis, Niobe, Nileus, Raymondaspis* and *Illaenus.* However, *Hypermecaspis* is present in the Tremadoc of Argentina, Britain and Norway (Harrington and Leanza, 1957, pp. 120-121) and its possible ancestor *Parabolinella* is widespread in North America (Henningsmoen, 1957, p. 133). The other four genera are well known in the Baltic Lower Ordovician, fragments of illaenids only being known in North America. The area in which many of the other genera arose is obscure, particularly in the case of raphiophorids, *Endymionia, Peraspis* and *Bronteopsis,* and whether to call them exotic or indigenous is quite uncertain. Cheirurid genera such as *Cyrtometopus* and *Ceraurinella?*, the encrinurid *Cybele,* and *Pterygometopus* are known from the Lower Ordovician of Scandinavia. In North America, fragments of cheirurids and cheirurid-like forms (e.g. Ross, 1951, pl. 35, figs. 3-17 19-21; Hintze, 1953, pl. 21, figs. 15-18) are rare in the Canadian. Thus while some of the cheirurids, encrinurids and dalmanitids of the Table Head may be exotic, others may be derived from indigenous stocks.

Faunal provinces. As has been shown, the Table Head fauna is like that of boulders in the Lévis Shale, the Shumardia Limestone, the Mystic Conglomerate, and the Antelope Valley Limestone of Nevada and formations of the same age in Utah. It clearly belongs within the bathyurid province (Whittington, 1963, p. 16, fig. 2), as the presence of komaspidids emphasises. The differences between the Table Head and contemporaneous Lower Head faunas seem to reflect differences in environments of deposition — dark limestone and shales versus pure white limestone of the Lower Head boulder. The genera listed above as typical of the Table Head may also be taken as typical of the bathyurid province at that time and in that environment. Genera common to provinces at the same and different times were discussed previously. New is the faunal link, shown by the presence of two olenid genera, between dark limestones and shales of the Table Head and shaly rocks in Bolivia. No such link is apparent to contemporaneous shales, sandstones and limestones in Argentina. Links with the asaphid province in Scandinavia were discussed before, and are reinforced by the record of *Bronteopsis* in the Table Head. Yet though *Niobe* is common to the two provinces, other asaphids are quite different — *Stegnopsis* n. gen. in the Table Head and *Megistaspis, Ogygiocaris, Asaphus, Pseudasaphus, Ogmasaphus, Homalopyge* and *Pseudomegalaspis* in Norway and Sweden.

The fauna of the calymenid-trinucleid province in Llanvirn time is approximately contemporaneous with the Table Head and of comparable richness, for species of some 40 genera are known in Britain and Bohemia. The resemblance between the faunas is slight (see table above), for only *Geragnostus, Ampyx, Triarthus* and *Raymondaspis* appear to be in common. The trinucleid, dionidid, cyclopygid and homalonotid family groups are known only in the calymenid-trinucleid province at this time, while the endymioniids, dimeropygids, komaspidids and bathyurids are peculiar to the bathyurid province. Other families — harpidids, asaphids, nileids, illaenids, calymenids, encrinurids, dalmanitids and pliomerids — are represented by quite different genera in the two provinces, suggesting that evolution was proceeding independently.

SUMMARY OF MORPHOLOGY AND CLASSIFICATION

Attention is drawn here to morphological features of special interest, and to certain taxonomic conclusions drawn from this study.

External and internal exoskeletal surfaces. These surfaces are exceptionally well preserved, the internal directly or as moulds. The patterns of fine lines, tubercles, pits and facets of eye surfaces are shown in many figures. The internal surface of the illaenids is finely granulate, the granules of two sizes (e.g. Pl. 45, fig. 19; Pl. 46, fig. 10; Pl. 51, figs. 9, 11).

Areas of muscle attachment. On the axial region of the cephalon and pygidium these areas are smooth and may be slightly impressed, as in *Galbagnostus galba* (Pl. 3, fig. 7; Pl. 4, fig. 8), *Niobe quadraticaudata* (Pl. 25, fig. 1; Pl. 26, fig. 4), *Illaenus gelasinus* n. sp. (Pl. 53, figs. 1, 7; Pl. 54, fig. 1) and *Raymondaspis turgidus* n. sp. (Pl. 59, fig. 7). These impressed areas may be visible on the internal mould. In other cases the areas may show as dark patches when photographed under alcohol (Pl. 12, figs. 5, 18, 20; Pl. 22, fig. 12).

A pattern of radiating, anastomosing ridges on the lateral regions of the exoskeleton is described in *Galbagnostus galba* (Pl. 3, fig. 14; Pl. 4, fig. 10), *Harpides* (Pls. 5-7), *Selenoharpes* (Pl. 8), and *Raymondaspis reticulatus* n. sp. (Pl. 57, fig. 13; Pl. 58, figs. 1, 7). Of exceptional interest is the pygidium of the latter species, showing that the ridges are arranged in relation to segmentation. These ridges are assumed (Öpik, 1961a) to be impressions of the caeca, ramified lateral extensions of the alimentary canal.

Median occipital organ. In the median occipital area of *Bronteopsis* (Pl. 55, fig. 4) and *Raymondaspis* (Pl. 55, fig. 9) are four tiny pits arranged in a square. A similar arrangement of pits is visible in the median occipital tubercle of certain odontopleurids (Whittington, 1956, pp. 177-178), and structures of this type are known in other trilobites.

Lateral genal area. In species of *Galbagnostus* n. gen. (Pl. 2, fig. 24; Pl. 3, figs. 13, 15; Text-fig. 2A), *Geragnostus* (Pl. 1, fig. 14) and *Trinodus* there is a smooth area situated in the outer, posterior part of the cheek, beside the border furrow. It is raised externally and on the internal mould. The smooth, outer surface is like that of the muscle areas, but these are impressed, not raised. The function of this area is problematical.

Lower lamella of fringe of Harpides. Billings' species *Harpides concentricus* (Pl. 6, figs. 2-4) is shown to be based on a portion of the lower lamella of the fringe of *H. atlanticus.* The structure of this lower lamella is like that recently described of a Norwegian species.

Hypostome. This plate in *Nileus affinis* (Pl. 31, figs. 1-6) is known almost in place. The long anterior wing is extended vertically and must lie close beneath the dorsal exoskeleton. No anterior pit (apodeme on inner surface) is present. The hypostome has the maculae situated close to the anterior margin — an unusual condition which suggests that the anterior lobe of the middle body is either much reduced or absent. Such a condition is like that believed to obtain in *Remopleurides* (Whittington, 1959, pp. 393-396, fig. 3). Other reasons for suggesting a relationship between nileids and remopleuridids are given.

The hypostome attributed to *Illaenus consimilis* (Pl. 52, figs. 6-13) has the macula smooth on the external surface, but showing hexagonal pits on the internal mould. This structure is like that described by Lindström (1901) and compared by him to that of the eye surface.

Homeomorphy. Raymond (1925, pp. 79-80) placed his new species *lineolata* in the asaphid genus *Niobe* without question, and Billings had pygidia of this species included under *N. morrisi.* The cephalon with genal spines, the thoracic segments, and particularly the furrowed pygidium with a smooth border are asaphid-like. However, the species *lineolata* is here regarded as the type of a new nileid genus *Peraspis,* the decisively nileid character being the lack of the median suture. In addition, the eyes abut against the axial furrow, the external surface bears fine raised lines, and there are only seven thoracic segments. The hypostome attributed to this species is also more nileid than asaphid in form.

Sexual dimorphism. Two trilobites occurring at the same horizon and differing in one or more characters have been thought to represent sexual dimorphs of one species (Whittington, 1963, pp. 23-24 and references). It may be that the two ''species'' of *Niobe* (Text-figs. 5, 6) described here, and *Illaenus marginalis* and *I. alveatus* from the lower Table Head, are such dimorphs.

Ontogeny. Small cranidia and transitory pygidia of a number of species are described together with size series of cranidia of *Endymionia schucherti, Triarthrus fischeri, Niobe quadraticaudata* and *Illaenus consimilis.* The ''lateral glabellar lobes'' in *Endymionia* appear abruptly at an early stage in the axial furrows, and become larger, an unusual mode of development for such lobes. Protaspides of an asaphid were found (Pl. 29, figs. 4-11) and are like those of younger species described by Evitt (1961).

Classification. Groups of characters considered to be of generic or specific rank are like those employed previously (Whittington, 1963, pp. 24-25). In dealing with the agnostids the problem presented by a partially effaced form, *Geragnostus fabius,* arose. Particularly on the internal mould characters are preserved which seem to justify this generic assignment. The new genus *Galbagnostus* could not have been discriminated if the exoskeleton had not been so well preserved, showing muscle areas of the glabella, the glabellar tubercle, the muscle pits behind the ''axis'' of the pygidium, and the caeca. The discovery and study of other well-preserved agnostid material will show how valid may be the bases on which this genus is erected.

Understanding of the genus *Shumardia* has been based on the European *S. pusilla.* The type species from Quebec is here redescribed (Pl. 16), including an entire specimen with the free cheeks in position.

The use of many new characters in asaphid taxonomy by Jaanusson make it difficult to evaluate species and genera that have not been critically revised. These difficulties are acute in dealing with the present asaphid material, and in the case of *solitarius* n. sp. and *huttoni* I have chosen to erect the new genus *Stegnopsis,* with *S. solitarius* as type. Restudy of stratigraphically older and younger species is needed to evaluate this choice. The weight to be placed on particular characters newly employed by Jaanusson is also questionable. The much greater width of the pygidial doublure is an important character in distinguishing species of *Pseudasaphus* from those of *Stegnopsis.* I have regarded this same character as of specific or subspecific value in considering species of *Niobe.*

The cephalon of the bathyurid *Acidiphorus spinifer* is described and proves to be like those of the type and other species of *Goniotelus,* and the latter genus is here regarded as a subjective synonym of *Acidiphorus.*

The lectotype of *Heliomera sol* (Pl. 63, figs. 1, 3, 4, 5) has been prepared to reveal the fixed cheek. As a result of this and other discoveries it is thought that *Heliomeroides* should be considered a subgenus of *Heliomera,* and the subfamily Heliomerinae merged into an enlarged concept of the Sphaerexochinae.

The new encrinurid genus *Miracybele* is based on *M. mira,* and almost the entire exoskeleton described. It shows, as other early encrinurids do, pliomerid-like characters.

Various species known only from cranidia are figured and briefly described. One (Pl. 59, figs. 10, 12-15) is like *Calymenidius* of the late Cambrian, and a calymenid. Two others (Pl. 19, figs. 13, 14, 18; Pl. 68, figs. 1-3) are indeterminate as to genus or even family.

SYSTEMATIC PALAEONTOLOGY

Introduction

A few of the trilobites described below are from the Lévis Shale, Quebec, and localities are given as fully as possible. The remainder are from the Table Head Formation. Localities are shown in Text-figure 1 and explained in a preceding section. An account of the stratigraphy (Whittington and Kindle, 1963) gives further details, and also explains how the earlier lettered divisions of Logan and Billings are related to the present formation. The horizon of all specimens is given in modern terms.

Dr. Thomas E. Bolton, Geological Survey of Canada, is preparing a catalogue of type specimens of trilobites in the Survey collections. I have followed him in regarding as syntypes the specimens, collected by James Richardson, which E. Billings studied. If there was originally a single specimen, or if the original of a figure is unequivocal, it is called a holotype. In other cases a lectotype is selected and the remainder termed paralectotypes.

Type and figured specimens are in the collections of the Geological Survey of Canada (GSC), the Peabody Museum, Yale University (YPM), and the Museum of Comparative Zoology (MCZ). Catalogue numbers are preceded by the appropriate letters as given in parentheses. GSC numbers 18248-18581 are from Kindle and Whittington's collection, the remainder of this collection being in MCZ.

Synonymies in this section are given in a shortened form, the generic and specific name being omitted if the specific name is the same as that of the species under consideration. References to figures 2 and 3 of Whittington and Kindle, 1963, are omitted unless the name has been changed. New systematic names are arbitrary combinations of letters, except that *Peraspis* n. gen. incorporates the initials of Percy E. Raymond.

TERMINOLOGY

Terms are used in the same sense as previously (Whittington, 1963), and most are defined in Harrington, Moore and Stubblefield (*in* Moore, 1959, pp. 0117-0126). Terms requiring comment are:

Glabellar tubercle, a median glabellar tubercle, situated in the posterior half, and best developed on the inner surface of the exoskeleton. Jaanusson (1953a, pp. 381-382) recognized the tubercle in asaphids and nileids, and it is here used in illaenids.

Paradoublural line is "a line on the dorsal test and lies directly above the inner margin of the doublure" (Henningsmoen, 1960, p. 210).

Family AGNOSTIDAE M'Coy, 1849

Discussion. Recent work by Öpik (1961b, pp. 52-55) and Palmer (1962, pp. F-11 to F-12) shows that the suprageneric classification of these trilobites is in a state of flux. The species described below may be considered to belong within this family as recently defined by Palmer, but the lines of descent from Cambrian to Ordovician agnostids are not yet understood. Pending clarification of some of the problems, subfamilial groupings are not used.

Genus GERAGNOSTUS Howell, 1935

GERAGNOSTUS LONGICOLLIS (Raymond, 1925)

Plate 1, figures 1-12, 14, 16, 17

Raymond, 1925, pp. 12-13, pl. 1, fig. 5 (not fig. 6).

Holotype. YPM 13054, internal mould of pygidium, from the isolated limestone.

Other material. Middle Table Head Formation: at type section, fairly common at 90 and 185 ft. above base; common in isolated limestone and on foreshore south of Table Cove.

Description. Raymond associated an incomplete cephalon of *Galbagnostus galba* with the holotype pygidium, but the entire specimen (Pl. 1, figs. 4-7, 9, 10) shows that the cephalon is of a different type. Raymond (1925, p. 11) also reversed the then generally accepted orientation of agnostids, and so considered the holotype to be a "cephalon." Raymond's view is not accepted today, particularly because of the evidence from ontogeny (Stubblefield, 1926, p. 366).

Comparison of the present illustrations with those of the recently described *G. clusus* (Whittington, 1963, pp. 28-32, pl. 1, figs. 1-17; text-fig. 3) shows that these two species are exceedingly alike, but can be distinguished by certain minor characters. In *G. longicollis* the outline of the cephalon and pygidium is subcircular, the maximum width at about half the length, and the anterolateral and posterolateral borders of uniform width. In *G. clusus* the maximum width of the cephalon is at the anterolateral corners, which are obliquely angulate, and the border is widest at this point. The pygidium of *G. clusus* likewise attains the maximum width at the posterolateral angle, at which point the margin is obliquely angulate and the border widest. The outline of the lateral lobe of the axial rings of the thoracic segments is slightly different in the two species, and the posterior portion of the pygidial axis in *G. longicollis* is relatively longer and marked off by a shallower ring furrow. No specimens of *G. longicollis* have the posterior portion of the axis expanded as in one specimen of *G. clusus* (Whittington, 1963, pl. 1, figs. 10, 11). These and other minor differences in convexities of parts combine to distinguish the species though they are obviously closely related. External surface is apparently smooth, while in some specimens of *G. clusus* a faint reticulation was observed on the external surface. Along the posterolateral margin of the cheek, immediately inside the border furrow, is a gently convex strip marked off by a faint furrow (Pl. 1, fig. 14). A similar strip in *G. clusus* is poorly preserved (Whittington, 1963, pl. 1, fig. 3).

G. longicollis is referred to *Geragnostus* for the reasons given when discussing *G. clusus*. One example of a pygidium (Pl. 1, figs. 13, 15, 18) in which the exoskeleton is preserved, differs from all other specimens in that the axis of the pygidium is relatively much shorter, and there is a faintly outlined protuberance on the posterior tip of the axis, behind which the axial furrow is deepened. Though no such protuberance has been observed on the outer surface of the exoskeleton of other specimens, internal moulds may show a faint tubercle at the tip of the axis (Pl. 1, figs. 1, 3, 16, 17). Whether or not this unique pygidium represents a variant of *G. longicollis* or a distinct but rare species, is not known. In the shortness of the pygidial axis, it approaches species of *Trinodus* (Whittington, 1950, pl. 68, figs. 4, 6).

GERAGNOSTUS FABIUS (Billings, 1865)

Plate 2, figures 1-23, 25, 26

Billings, 1865, pp. 298-299, fig. 289.

Lectotype (here selected). GSC 704c, internal mould of cephalon from Daniel's Harbour. Paralectotypes: GSC 704a, b, d, g, pygidia; GSC 704, 704f, cephala; same locality as lectotype.

Other material. From the middle Table Head Formation, this species appears first 185 ft. (not at 155 ft., Whittington and Kindle, 1963, fig. 3) above the base. It is less common than *G. galba* and *G. longicollis* at exposures south of Table Cove and in the isolated limestone, but is the only agnostid present in the higher beds at the type section, in bed 4 at Black Cove, and the boulders at Daniel's Harbour.

Description. Anterior half of glabella extremely faintly outlined on external surface (Pl. 2, fig. 4); on internal mould (Pl.

2, fig. 20) it is distinctly outlined by shallow axial and preglabellar furrows. Occipital ring composed of short (sag.) median band and large triangular lateral lobes, shallow furrow defining proximal side of this lobe not straight but sinuous. Low median tubercle situated at about one-third length of glabella. Low median ridge on most posterior part of median glabellar lobe where it projects between the lateral occipital lobes. Faint transverse glabellar furrow runs in a curve that is concave forward, and is situated immediately in front of the median tubercle; on internal mould the furrow is continued forward and outward almost to the axial furrow. Convex cheeks descend steeply laterally, slope of preglabellar area less steep. Cephalic border relatively narrow and uniform in width anteriorly and anterolaterally, posterolaterally becoming narrower. At genal angle border curves around to meet the narrow posterior border, no genal spine at junction (Pl. 2, figs. 8, 9, 16, 20, 21).

Second thoracic segment (Pl. 2, fig. 10; first segment is pushed beneath cephalon) with semicircular lateral axial lobe, pleura curved forward and outward, deep pleural furrow situated nearer anterior than posterior margin and curving out to tip.

Pygidium with axis faintly outlined and not subdivided on external surface (Pl. 2, fig. 7); on internal moulds (Pl. 2, figs. 3, 26) furrows are deeper. First ring furrow absent medially, lateral part of ring slightly inflated. Second ring furrow continues across axis, medial tubercle situated immediately in front of this furrow. Second ring furrow is situated at about half length of axis, posterior portion of axis tapering and gently convex, at tip a low median tubercle projects over the furrow. Pleural regions gently convex, sloping most steeply laterally, gently posteriorly, border similar in width and outline to that of cephalon, no border spine.

External surface of exoskeleton apparently smooth, no evidence of convex region at posterolateral margin of cheek.

Discussion. From the relatively few specimens available, little evidence of individual variation has been observed. The original of Plate 2, figure 23, appears wider and shorter than typical pygidia. This appearance may be an expression of variation or of distortion during preservation. Small holaspid individuals appear little different from the largest. One enrolled specimen (Pl. 2, figs. 14, 15, 18, 19) is a meraspid degree one, the transitory pygidium including the portion that is to become the second thoracic segment. This portion is clearly outlined, the axial ring displaying the lateral lobes. The remainder of the axis of the transitory pygidium is undivided. The posterolateral and posterior pygidial borders appear to be relatively wider than in holaspides. The cephalon is much like that of larger individuals, but the convexity of this meraspid is greater than in holaspides.

In the characters of the glabella and pygidial axis as revealed by internal moulds, this species is a typical *Geragnostus*. The partial effacement of axial furrows on the external surface, the narrow borders and lack of genal and pygidial spines, distinguish this species, and may have led Raymond (*in* Schuchert and Dunbar, 1934, p. 69) to regard it as representing a distinct genus, for he lists it as "*Diplaspis*" (a *nomen nudum*) *fabius*. Effacement of furrows occurs in many lines of agnostids (Öpik, 1961b, pp. 53-54), but the characters in common between *G. fabius*, *G. longicollis* and *G. clusus* seem to place generic relationship beyond doubt. *G. fabius* also shares with *G. longicollis* and other species the character of the slight projection at the tip of the axis.

G. fabius appears rather rarely at the upper limit of the known stratigraphic range of *G. galba* and *G. longicollis*, and ranges upward for some 30 feet in the type section. This species thus replaces the other two in time, and is particularly characteristic of the fine grained, muddy, black, thin-bedded limestones of the highest part of the middle Table Head Formation.

Genus GALBAGNOSTUS n. gen.

Type species. Agnostus galba Billings, 1865.

Diagnosis. Differs from *Geragnostus* in that median glabellar tubercle is situated far forward, no transverse glabellar furrow but six pairs of muscle areas, 1p on the occipital lobes, 4p beside the axial furrows at the mid-length, 6p flanking the median tubercle. Shallow median depression in preglabellar field. Posterior lobe of pygidial axis with median ridge, deep excavation in furrow behind this ridge. Low, subtriangular raised area on pleural region immediately behind the deep part of the furrow, outlined by muscle spots; pleural region behind axis inflated. Faint pattern of radiating caeca visible in axial and border furrows.

Discussion. These characters distinguish the type species *Galbagnostus galba* from such species of *Geragnostus* as *G. longicollis*, *G. clusus* and *G. fabius*, well-preserved specimens of all of which are available. They presumably also distinguish it from other species of *Geragnostus,* but it is difficult to judge from published descriptions. As discussed below, there are similarities between *G. galba* and *Trinodus elspethi* which may indicate a relationship, but the nature of this is as yet uncertain.

GALBAGNOSTUS GALBA (Billings, 1865)

Plate 2, figure 24; Plates 3, 4; Text-figure 2

Billings, 1865, pp. 297-298, fig. 288.
Raymond, 1925, pp. 11-12, pl. 1, fig. 6.

Lectotype (here selected). GSC 689b, from middle Table Head Formation at type section. Paralectotypes include 689, incomplete cephalon, 689a, c-e, pygidia, from same locality and horizon.

Other material. From middle Table Head Formation, at type section, specimens are rare 17 feet above base, relatively common at 90 and 185 feet above base, abundant in the isolated limestone and exposures on foreshore at Table Cove. Also included here is YPM 13051, the original of Raymond, 1925, pl. 1, fig. 6, an incomplete cephalon which he regarded as the pygidium of his species *longicollis.*

Description. No entire specimen has been found, but the cephalon and pygidium here associated bear the reticulate pattern of raised ridges on the external surface inside the borders.

Glabella slightly longer (sag.) than maximum width across occipital lobes, tapering forward, and rounded at blunt tip. The median band of the occipital ring is short (sag.) and deeply indented by the backwardly projecting, carinate median glabellar ridge. Occipital lobe large, triangular, deeply indented at inner anterior margin by muscle area 1p (Text-fig. 2a). Median glabellar tubercle situated far forward, at about one-sixth the length from the anterior margin. At about the midlength of the glabella the axial furrows are widest, and there is an extremely faint depression, smooth on the outer surface, in the side of the glabella close to the axial furrow. This is muscle area 4p. There is a total of six pairs of muscle areas on the glabella (Pl. 3, figs. 7, 15; Text-fig. 2a), all smooth on the external surface, but only the 1p pair is slightly impressed. Areas 6p flank the median glabellar tubercle. Cheeks and preglabellar field form a continuous pleural region, convex and sloping vertically laterally. A faint shallow median depression crosses the preglabellar field. The posterior border (Pl. 3, fig. 3) commences as a narrow ridge beneath the midpart of the occipital lobe, and extends out horizontally to the fulcrum, where it widens and is flexed down vertically. There is no genal spine at this point (Pl. 3, fig. 15). Below the fulcrum the narrow border curves forward to become the horizontal lateral border, which widens forward to the anterolateral and anterior borders which are the

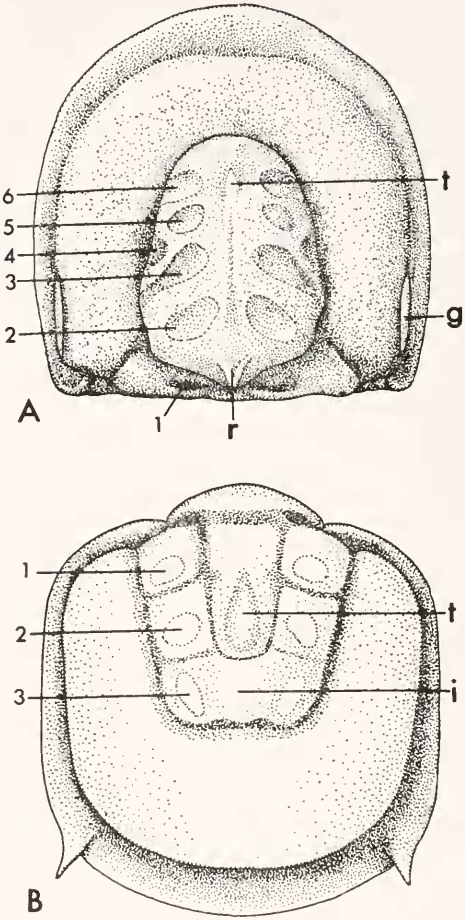

FIG. 2. *Galbagnostus galba* (Billings), middle Table Head Formation. A, dorsal view of cephalon; B, dorsal view of pygidium, c. X 15. Abbreviations: 1-6, muscle areas; g, lateral genal area; i, median ridge of third axial ring of pygidium; r, median posterior ridge of glabella; t, median tubercle.

widest. These borders are separated from the cheeks and preglabellar area by a broad, deep border furrow. At the outer, posterior margin of the cheek, beside this border furrow, is an ovate, smooth, gently inflated area (Pl. 2, fig. 24; Pl. 3, fig. 15). This area appears as a flat platform on the internal mould (Pl. 3, figs. 2, 13); on the external surface it distinctly projects beyond the adjacent part of the cheek. On internal moulds of the cephalon (Pl. 3, fig. 14) an extremely faint pattern of fine, radiating ridges separated by grooves in which there may be shallow pits, is seen on the cheeks, preglabellar area and borders. This pattern is best seen in the preglabellar furrow and the anterior and anterolateral border furrows. On the external surface (Pl. 3, figs. 7, 15) is a reticulate pattern of raised ridges which does not extend on to the borders, nor the deepest parts of the furrows. Along the midline of the glabella these raised lines are arranged roughly longitudinally between the median tubercle and the median ridge immediately in front of the occipital ring. Median glabellar tubercle, muscle areas, and lateral genal areas are smooth.

Pygidium with well-defined axis tapering back and bluntly terminated, reaching just beyond half the length (sag.). Axis divided into three rings which are of equal length. First ring not defined by ring furrow medially, and divided into three equal parts by longitudinal furrows. These furrows continue on to midpart of second ring, which is raised as a large, oval tubercle. Second ring furrow runs behind this tubercle. Third and posterior ring of axis with faintly raised median longitudinal ridge of similar width to the tubercle on the preceding ring; tip of axis behind this ridge excavated where axial furrow is considerably deepened. Pleural regions convex, and distinctly inflated behind axis, and especially so behind median posterior part of axis where there is a low, raised tubercle. This raised region immediately behind the axis is best seen on the internal moulds (Pl. 4, figs. 3, 7, 10) where it is roughly triangular in outline, gently convex, and outlined by an extremely shallow furrow in which there are a few tiny pits, the deepest pit being at the pointed posterior tip. Anterior border of pleural region a strongly raised ridge, which is faceted anterolaterally, and separated from pleural region by a deep border furrow. Doublure is flat and extends beneath border; posterolateral border spine is fold in dorsal exoskeleton only, not in doublure, and extends beyond border for a short distance. External surface inside borders bearing reticulate pattern of raised lines, this pattern being absent in furrows and on the muscle areas (Pl. 4, figs. 8, 9; Text-fig. 2b) and median tubercle of second axial ring. On internal moulds an extremely faint pattern of fine, radiating caeca, separated by faint grooves or lines of pits, is visible. As on the cephalon, the pattern of caeca is best seen where it crosses the border furrows (Pl. 4, figs. 7, 10).

Discussion. Muscle areas in agnostids have frequently been illustrated and commented on (Westergaard, 1946, p. 96, pl. 16, figs. 1, 2; Palmer, 1955, pl. 20, figs. 13-15; Öpik, 1961a, figs. 2, 15, 16). They may take the form of paired depressions in the axial regions, or apparently sometimes paired convex regions, and on the internal mould may appear as depressed or raised regions, sometimes roughened. The smooth areas present on the glabella of the present species are like those seen in silicified specimens of *Trinodus elspethi* from Virginia (Cooper 1953, pl. 1, fig. 7). In this latter species the number of areas on the glabella in front of the occipital ring is the same, but the arrangement is different — the median glabellar tubercle is situated at about half the length, and the five pairs of areas are subradially arranged with respect to this tubercle. Muscle areas on the three rings of the axis, visible as smooth patches, are present in *T. elspethi* (Cooper, 1953, pl. 1, fig. 9) much as they are in *G. galba*. Unique to the present species are the tiny pits, referred to here as muscle pits, that surround the low triangular convexity immediately behind the axis of the pygidium. Similar lines of tiny pits, converging backward, have recently been described on the axis of the pygidium of *Glyptagnostus* (Öpik, 1961a, text-figs. 15, 16), and presumably those in *G. galba* are similar structures. If so, they must be on the axis of the pygidium, and thus the true axis must include these areas and so extend a short distance behind the area outlined by deep furrows and referred to in this description as the "axis." The pattern of caeca in agnostids has been described and discussed by Öpik (1961a), and the faint traces of radiating ridges shown by the internal moulds of the present material seem to represent the same structure.

The smooth, convex, area on the outer, posterior corner of the cheek, well developed in this species, and less conspicuously visible in species of *Geragnostus* (Pl. 1, fig. 14; Whittington, 1963, pl. 1, fig. 3) does not appear to have been described before in agnostids, and its function is not clear. It is like the muscle areas of the axis in being smooth externally, but unlike them in being convex on the external surface, and visible on the internal mould as a slightly raised, flattened platform.

The distinctions between *Geragnostus* and the new genus have been emphasized in the diagnosis, but the many characters in common may be indicative of relationship. There is also the possibility that there may be a relationship between *G. galba* and certain species presently referred to *Trinodus*, particularly *T. elspethi* (Cooper, 1953, pl. 1, figs. 1-12). The latter species has the glabellar tubercle situated at about the midlength; the pygidial axis is even shorter, and does not appear to display the convexity behind the axis, though there may be a faint median ridge on the terminal portion of the axis. The external surface bears the reticulate pattern of raised lines, and the number (but not the arrangement) of the muscle areas is similar. It is also notable that the lateral genal area appears to be present in *T. elspethi* (Cooper, 1953, pl. 1, fig. 6).

Family HARPIDIDAE Hupé, 1953

Genus HARPIDES Beyrich, 1846

HARPIDES ATLANTICUS Billings, 1865

Plates 5-7

Billings 1865, pp. 281-282, fig. 267.

Harpides concentricus Billings, 1865, p. 282, fig. 268.

Holotype. GSC 674, 674c, counterparts of fragment of cranidium, original of Billings, 1865, fig. 267, from Daniel's Harbour.

Other material. GSC 674a, b, counterparts of glabella and surrounding part of cranidium; GSC 672, 672b, counterparts of part of lower lamella of fringe, holotype of *H. concentricus* Billings, 1865, fig. 268; GSC 672a, similar fragment; all from same locality as holotype of *H. atlanticus.* In the type section at Table Point this species is rare at 17, 185 and 265 feet above the base of the middle Table Head Formation; it is fairly common in the isolated limestone and at Table Cove.

Description. Glabella subtrapezoidal in outline, maximum width across basal glabellar lobes slightly greater than length (sag.). Occipital furrow curves gently forward medially where it is shallow; distally it is deep; occipital ring convex, bow-shaped outline to posterior margin. Lateral glabellar furrow 1p deep, straight, diagonally directed and outlining a subtriangular basal lobe; proximal portions of these basal lobes joined across midpart of glabella by a low ridge, at the summit of which is a median tubercle. Lateral glabellar furrows 2p and 3p short, shallow, directed inward and only slightly backward; lateral lobe 2p suboval in outline and gently inflated, lateral lobe 3p much shorter (exs.) and less convex. Anterior margin of frontal lobe gently curved so that glabella is bluntly terminated. Axial furrow shallow beside occipital ring, beside lateral lobe 1p expanding to the deep, flat-based, crescentic ala; in front of outer end of lateral furrow 1p axial furrow is deep and narrow, but at eye ridge it becomes shallow and continuous with the faint preglabellar furrow. Cheek lobe convex, quarter-circle in outline, width at posterior margin slightly less than maximum width of glabella, cheeks united anteriorly by depressed concave preglabellar field. Prominent, crescentic eye lobe situated well out on cheek lobe, opposite outer ends of lateral glabellar furrows 1-3, palpebral lobe sloping inward and with gently convex rim, outward-facing slope of eye lobe steep. Prominent eye ridge gently curved, running inward and slightly forward to reach axial furrow opposite posterior part of frontal glabellar lobe. Brim broad and concave upward, the width (sag. and tr.) constant and at the posterior margin, greater than the width (tr.) of cheek lobe or glabella. External rim of upper lamella not raised above adjacent parts, continuous at genal angle with gently convex posterior border of cheek lobe. Lower lamella of fringe convex downward, external and posterior rims like those of upper lamella, external surface bearing 7 or more concentrically arranged narrow ridges, these ridges (or girders) placed progressively closer together as the inner margin of the lamella is approached; the inner 3 or 4 ridges thus placed quite close together anteriorly and merging laterally. External surface of cheek lobe and lamellae traversed by radiating, anastomosing genal caeca which extend from the axial and preglabellar furrows to the external rim, becoming reduced in convexity as they approach the rim so that they merge into the flattened external rim. The caeca radiate from the axial furrow opposite the anterior one-third of the glabella and they appear to run under and beside the eye ridge and eye lobe, and posteriorly to the latter they give the appearance of sweeping around the cheek behind it (Pl. 5, fig. 3; Pl. 7, figs. 1, 4). Only at one point, midway along the anterior side of the eye ridge, does a caecum appear to branch from this ridge. In front of the glabella the caeca curve toward each other and there are several junctions, but distally all the caeca tend to diverge, branch, and to be more widely separated from each other. Of variable intensity is a ridge running along the outer side of the preglabellar furrow, between the proximal ends of the eye ridges. On the upper lamella of the fringe the inner margin is marked by the appearance of a single line of pits between the caeca; beyond the inner one-third of the fringe the rows of pits become double and irregularly placed between the divergent caeca. On the lower lamella (Pl. 6, figs. 2-4) the caeca are less convex, but are clearly outlined by the similarly arranged pits. On the upper lamella concentric smooth bands are outlined by gaps in the radial lines of pits (Pl. 5, fig. 3); these bands are placed more closely together towards the inner margin of the fringe. Their number and positions suggest that they correspond to the girders of the lower lamella. A genal ridge originates at the posterolateral margin of the eye lobe (Pl. 5, fig. 3), and runs outward and slightly backward toward the genal angle, becoming narrower and fainter distally, but traceable most of the way to this angle.

Except in alae and axial furrows, a fine granulation is present on the external surface including the rims and caeca of the fringe. On the glabella, posterior border, caeca, and eye ridge larger tubercles are irregularly scattered. These tubercles vary in size, and appear to be faint or absent on all but the outermost part of the gently convex, oval second lateral lobe (Pl. 6, fig. 1). On the palpebral lobe there is a conspicuous group of these tubercles, largest at the outer margin but the outer slope of the eye lobe appears to be smooth, and does not show any sign of eye facets (Pl. 7, figs. 3, 4).

Discussion. Henningsmoen (1959, pp. 166-169, pl. 2, figs. 5-11) has redescribed *Harpides rugosus* from Tremadoc of Norway, illustrating for the first time the nature of the lower lamella. As in *H. atlanticus* it bears several girders, and is crossed by radiating caeca and lines of pits. It is quite clear from the arrangement of these caeca and pits, the granulation of the external surface, and the form, that such specimens as the originals of Plate 6, figures 2-4, represent the lower lamella of the fringe, and not a different species of the genus as originally thought by Billings (1865, p. 282). Species of *Harpides* are characteristic of Tremadoc rocks of the world (Harrington and Leanza, 1957, p. 196, fig. 103, 1; Rasetti, 1952, p. 801; Troedsson, 1937, pp. 69-70, pl. 8, fig. 2; additional references in Henningsmoen, 1959), but specimens are found only rarely and in a fragmentary state in rocks of Lower Ordovician age (e.g. Tjernvik, 1956, p. 268), and the present species appears to be the youngest known. It is distinguished from earlier species by the relatively wide and short glabella, the position and prominence of the eye lobe, the outward and backward direction of the eye ridge, and the convergence of the caeca in the preglabellar area.

The genal caeca of *Harpides atlanticus* have been described above as radiating out from the axial furrow beside the anterior part of the glabella, and as showing no obvious connection with the eye ridge. None appears to originate from the occipital ring, and there is no sign of separate groups arising opposite each glabellar furrow, as in the Cambrian *Papyriaspis* (Öpik, 1961a, p. 424, fig. 12). Öpik follows Hupé (1953, pp. 83-84) in believing that certain of the caeca are closely connected with palpebral lobe and eye ridge, and suggests also a connection with the parafrontal band (Öpik, 1961a, pp. 424-425). A parafrontal band is present in *H. atlanticus* (Pl. 5, fig. 1; Pl. 7, fig. 2), but it appears to me at least arguable that the anterior caeca run from this band and the eye ridge and palpebral lobe. One caecum (Pl. 7, fig. 4) does appear to branch from the eye ridge, but others may be interpreted as running uninterrupted beneath the eye ridge and lobe, and connection between caeca and parafrontal ridge is not beyond dispute, especially where this ridge is faint (Pl. 7, fig. 1).

The pattern of genal caeca in *Harpides* is thus like that in such harpids as *Selenoharpes* (Pl. 8, figs. 1, 4) in its seeming independence of eye ridge and lobe, in its point of origin, and in running out to the margin. In both genera the genal ridge runs independently of the caeca.

Family HARPIDAE Hawle and Corda, 1847

Genus SELENOHARPES Whittington, 1950

SELENOHARPES SINGULARIS n. sp.

Plates 8, 9

Holotype. GSC 18402, almost complete cephalon, middle Table Head Formation, Table Cove.

Other material. Parts of 10 additional cephala from same locality and horizon.

Discussion. This rare species, known from only one locality, is closely related to, but not exactly like either *Selenoharpes fragilis* (Raymond) or *S. vitilis* Whittington (1963, pp. 32-35, pl. 1, figs. 18-20, pls. 2, 3). In various minor characters the cephalon differs from either of the species named — the outline is subcircular, the brim relatively narrower, sloping gently downward outside the girder and becoming flat peripherally; the cheek lobes project relatively farther anterolaterally, so that the anterior margin of these lobes and the depressed preglabellar field is transverse, not curved convexly forward; the anterior part of the cheek lobe is more convex, projecting upward so that there is a steep slope into the axial furrow; the band on the upper lamella of the fringe corresponding to the girder is relatively more pronounced, and curved back behind the genal margin to meet the internal rim of the fringe at about half the length of the prolongation. The few specimens are insufficient to show much of individual variation. One incomplete cephalon (Pl. 9, figs. 4, 6) is similar to the holotype except that the brim outside the girder slopes much more steeply outward and downward. In this particular character it approaches *S. fragilis,* but is different from it in the cephalic outline and the relative narrowness of the brim (compare Pl. 9, figs. 4, 6, with Whittington, 1963, pl. 2, figs. 1-3). In specimens referred to *S. vitilis?* (Whittington, 1963, p. 34, pl. 3, figs. 1, 5) the prolongation in dorsal view is much less strongly incurved than in typical specimens, and the girder reaches the internal rim at about half the length. These characters of the prolongation resemble those typical of *S. singularis,* but in other characters mentioned above the new species is not like *S. vitilis?*

In one small, incomplete cephalon (Pl. 9, figs. 2, 3, 5) the glabella is parallel-sided, the eye lobe prominent and situated far outward and forward on the cheek lobe, and the prolongation of the fringe relatively much shorter than in large cephala. Thus during growth the glabella widens posteriorly and the prolongations increase in length, trends which characterize the development of *Dolichoharpes reticulata* (Evitt, 1951, p. 612).

Family RAPHIOPHORIDAE Angelin, 1854

Genus LONCHODOMAS Angelin, 1854

LONCHODOMAS NORMALIS (Billings, 1865)

Plate 10

Billings, 1865, pp. 295-296, fig. 286.
Raymond, 1925, pp. 38-39.

Lectotype (here selected). GSC 692, incomplete cranidium, from Daniel's Harbour. Paralectotypes: GSC 692b, c, e, cranidia; GSC 692a, d, f, g, j, k, l, pygidia; same locality.

Other material. GSC 693b, cranidium, 693e, f, pygidia, from middle Table Head Formation, included by Billings in *Ampyx laeviusculus.* This species is most abundant in the type section of the middle Table Head Formation, less so in the isolated limestone and at Table Cove.

Description. Outline of glabella diamond-shaped, maximum width at about one-third the length from the anterior end, occipital ring wide, flat and sloping gently down to occipital furrow. Immediately in front of broad, shallow occipital furrow is short (sag. and exs.) basal ring of glabella, best outlined on internal moulds (Pl. 10, figs. 1, 14) by shallow depression of first lateral furrow, and extremely faint furrow connecting these areas across the median part of the glabella. A short distance in front of furrow 1p is lateral furrow 2p, a larger, less deeply impressed (in internal moulds) area situated higher up the side of the glabella. Median line of glabella may be faintly carinate. Anterior pit a deep and narrow slit situated at anterolateral margin of glabella, frontal lobe of glabella extended in long, tapering prismatic spine. Fixed cheek subtriangular in outline, posterior border flat and sloping inward to the posterior border furrow, which bears a deep pit distally. Along anterior margin of cheek is a broad, flattened border which runs inward to the base of the glabellar spine and is defined by a sharp change in slope (Pl. 10, fig. 10). Laterally fixed cheek bounded by gently sigmoidal line of facial suture, which runs forward along the margin of the anterior border. Two examples of a hypostome which may belong to this species are subdiamond-shaped in outline, with narrow, gently convex borders. The middle body is evenly convex, and only the most posterior part is less strongly convex and apparently represents the posterior lobe.

Thorax of five segments, first segment relatively longer (sag. and exs.) than those following it. Axis is of constant width, thorax widest at second segment, from here tapering both anteriorly and posteriorly. Shallow pleural furrow runs out to fulcrum, at which pleurae are bent vertically down. Pygidium triangular in outline, length about two-thirds of width (tr.), posterolateral margin almost straight. Axis gently convex, standing above horizontal pleural regions, tapering back and running to obliquely angulate posterior tip of pygidium. Narrow ridge along posterolateral margin of pleural region, border bent vertically down, broad. First pleural furrow narrow and deep, running out to the facet in a curve that is concave forwards. On external surface (Pl. 10, fig. 7) axis of pygidium shows only articulating furrow, but muscle areas may appear as darker spots (Pl. 10, fig. 5). There are two pairs of such spots, the outer the larger and close to the margin of the axis, the inner pair smaller and joined by a faint line across the median region. On internal moulds (Pl. 10, fig. 4) these muscle areas may be represented by faint depressions. About 8 ring furrows are indicated by these paired muscle areas. External surface of exoskeleton smooth, except for fine, subparallel lines that traverse the angles of the glabellar spine, the border of the pygidium, and the borders of the hypostome. On internal moulds (Pl. 10, figs. 10, 14) a faint pattern of genal caeca may be seen on the cheek, running out from the axial furrow at the midlength of the glabella toward the genal angle.

Discussion. The cranidium, thorax and pygidium exhibit the typical characters of *Lonchodomas* (Whittington, 1959, pp. 460-463, 473-479, pls. 32, 33, text-fig. 8, and references therein), including the size and arrangement of the muscle areas. Some specimens show faintly (Pl. 10, fig. 10) the muscle area at the margin of the glabella where it is widest. Distinctive of this species appears to be the well marked anterior border of the fixed cheek, and the relatively long, triangular pygidium with the narrow raised rim. The only other hypostome of *Lonchodomas* that has been described is that of *L. carinatus* (Whittington, 1959, pl. 32, figs. 6, 8, 9, 12, 17) and it is also sub-octagonal in outline, but relatively broader and with a larger posterior lobe of the middle body. *L. normalis* is considerably older than most species of the genus, and is not like the younger species from the Chazy described by Raymond (1905, pp. 332-334, pl. 10, figs. 3-7; 1910, pp. 216-217, pl. 32, figs. 3-7). In the Chazy species the glabella is elongated in front of the remainder of the cranidium, and the pygidium is relatively shorter and less triangular in outline. Raymond referred his species to *L. halli* (Billings, 1861), the type of which came from Highgate Springs, Vermont. Material from this locality which I recently examined (Whittington, 1959, p. 479) shows that this species has the hooked genal spine similar to that of *L. carinatus,* and is probably of the same age. Thus it is uncertain that the Chazy species should be referred to *L. halli,* but in any event it appears to be quite different from the Table Head species. Still younger species such as *L. carinatus* and *L. mcgeheei* (see Sutherland

and Amsden, 1959) lack the anterolateral cranidial border and have a much shorter pygidium displaying several pleural furrows. *L. politus* Raymond, 1925 (pp. 39-40, pl. 2, figs. 8-10; Cooper, 1953, pp. 18-19, pl. 6, figs. 1, 2, 7, 8, 9, ?not 5, 6) displays the anterolateral border but has an otherwise different cranidium in which the suture curves inward across the lateral part of the cheek. The pygidium of *L. politus* is relatively short and shows 3 pleural furrows.

LONCHODOMAS CLAVULUS n. sp.
Plate 11

Holotype. GSC 18413, incomplete and largely exfoliated cranidium from 17 feet above base of middle Table Head Formation at type section.

Other material. Quite abundant 17 feet above base of middle Table Head Formation at type section, one pygidium from 50 feet above base; at Table Cove this species is about one-third as abundant as *L. normalis;* one pygidium comes from the isolated limestone.

Description. Outline of glabella in dorsal aspect like that of *Lonchodomas normalis,* but occipital ring slopes more steeply forward to occipital furrow, and laterally is joined by a wider, steeply sloping band to the posterior border. The basal glabellar ring is more prominent in internal moulds, the muscle areas appear similar except that 2p appears to be relatively large. In lateral view (Pl. 11, fig. 2) the frontal glabellar spine is seen to arise some distance above the anterior border, and to be directed forward and slightly upward, whereas in *L. normalis* (Pl. 10, figs. 6, 11) the glabellar spine arises immediately above the anterior margin and is horizontally directed. Anterior part of cheek curves down to sutural margin, and merges with narrow preglabellar field, and there is no broad flat border (compare Pl. 11, fig. 5 with Pl. 10, fig. 10). On the internal mould, (Pl. 11, figs. 5, 13) cheek is crossed by two or three faint genal caeca, which arise at the axial furrow a short distance in front of muscle area 2p and diverge slightly as they run out toward the genal angle. Doublure (Pl. 11, fig. 9) a plate which joins the fixed cheeks and is widest anteriorly, and there is a median furrow. The anterior margin is obliquely angulate, the rounded tip lacking the notch seen in *L. carinatus* (Whittington, 1959, pl. 32, figs. 2, 3). The doublure is seen to extend on the left side (Pl. 11, fig. 9) in a gently curving course and then is broken, so that if it includes part of the under side of the genal spine, it only includes the slightly curved proximal portion. Hypostome shield-shaped, convex middle body divided by faint median ridge, which becomes more prominent and broader posteriorly; small macula at posterolateral corner, posterior lobe small. Anterior border broad, projecting steeply downward in front of anterior furrow, laterally and posteriorly border narrow, widening posterolaterally where it is extended on the dorsal side as a small, pointed posterior wing. External surface of exoskeleton apparently smooth, except along angles of glabellar spine, inner margin of doublure, and borders of hypostome, which are traversed by fine terrace lines. On internal mould surface appears finely pitted (Pl. 11, fig. 13).

Pygidium differs from that of *L. normalis* in that pleural region is considerably inflated so that adjacent to the axial furrow it slopes steeply forward to the pleural furrow, and slightly less steeply posteriorly; vertical border much broader and bearing a deep, broad posterior notch. On axis ring furrows are most conspicuous on internal mould, up to ten visible. These furrows are outlined by two pairs of muscle areas, the inner pair joined by a narrow band; in front of the most anterior pair is a conspicuous, elongate, median depressed area, this area lying immediately behind the deep articulating furrow. External surface apparently smooth, except for fine terrace lines on border. On internal mould, surface of axis and pleural regions appears finely pitted.

Discussion. In the type section of the Table Head Formation this species is the only one in the lower 20 feet; above here it becomes rare and is not known more than 50 feet above the base, being replaced by the more abundant *L. normalis*. In the exposures at Table Cove this species is moderately abundant. Since this is the only raphiophorid present in the lowest part of the middle Table Head, there can be little doubt that the hypostome belongs in this species. In general form it is more like that attributed to a species of *Ampyx*, *A. virginiensis*, than that attributed to a species of *Lonchodomas*, *L. carinatus* (Whittington, 1959, pl. 29, figs. 9, 10, 12-16; pl. 32, figs. 6, 8, 9, 12, 17). The anterior border is broader than that of *A. virginiensis* and projects more prominently and the faint subdivision of the median lobe into two lateral lobes is not seen in the Virginia species.

The position and direction of the frontal glabellar spine, course of the suture across the outermost part of the cheek, and relatively long, convex pygidium, combine to distinguish this species from Chazyan and younger species referred to in the discussion of *L. normalis.*

Genus AMPYX Dalman, 1827

AMPYX LAEVIUSCULUS Billings, 1865

Plate 12, figures 1-12

Billings, 1865, p. 295, fig. 285.

Lectotype (here selected). GSC 693, pygidium with exoskeleton from type section, middle Table Head Formation. Paralectotypes: GSC 693a, c, internal moulds of pygidia (693b, e, f are here referred to *Lonchodomas normalis,* and 693d to *Ampyxoides semicostatus*).

Other material. Only from thin layer of lime sand about 90 feet above base of type section, middle Table Head Formation. Raymond (1925, pp. 36-37) based his description on material collected by Schuchert and Twenhofel from "zone 13, N_3, at Table Head." These specimens (YPM 3100/20) are in a black calcareous shale, and are mostly *Lonchodomas normalis*, a few being *Ampyxoides semicostatus.*

Description. Cranidium, free cheek and pygidium are typical of the genus (Whittington, 1950, pp. 554-556, pl. 74, figs. 3-9, text-fig. 6). The cranidium shows the muscle areas as depressions in the internal mould of the glabella, the latter relatively convex anteriorly, with a long downward slope below the base of the glabellar spine. Particularly in lateral profile (Pl. 12, fig. 8), as well as in dorsal view, this cranidium is extremely like that of *A. camurus* (Whittington, 1959, pl. 30, figs. 15, 19) from the Liberty Hall facies of the Edinburg Formation, Virginia. In the characters in which it resembles *A. camurus*, the cranidium differs from that of *A. virginiensis* (Whittington, 1959, pp. 465-469, pl. 29; pl. 30, figs. 1-14, 16, 17, 20-30; pl. 31) — a second species from the Edinburg Formation. Width of pygidium is about 2½ times length (sag.), the axis is relatively narrow and gently tapering, the tip not well defined. The broad border slopes vertically downward. This pygidium is also like that of *A. camurus* in dorsal aspect, differing chiefly in that the border is less steeply sloping in the Virginia species. Two examples of a hypostome which may belong to this species are subdiamond shaped in outline, with narrow, gently convex borders. The middle body is evenly convex, and only the most posterior part is less strongly convex and apparently represents the posterior lobe.

Genus AMPYXOIDES n. gen.

Type species. Ampyx semicostatus Billings, 1865.

Diagnosis. Differs from *Ampyxina* (Whittington, *in* Moore, 1959, p. O426, fig. 329, 1; 1959, pp. 481-487, pl. 28, figs. 10, 11, 13; pls. 34, 35) in that alae are lacking, and there is a frontal glabellar spine which is sub-square in cross-section and curves gently upward. Pygidium with axis that tapers to narrow (tr.) tip, pleural furrows almost straight, distally curving slightly forward (not backward), pleural ribs flattened, after first furrow defined only distally, extremely faint interpleural furrows.

Discussion. The type species is a typical raphiophorid (Whittington, 1959, pp. 460-463) having a rather *Ampyx*-like glabella except that the frontal spine is square in cross section, not rounded, five thoracic segments, the first longer (sag. and exs.) than those following, the pleural regions of the pygidium not like those of *Ampyxina.* The muscle areas on the glabella are like those of *Ampyx* and *Lonchodomas,* only the outer parts of 2p and 3p being represented by depressions in the external surface, the areas extending far inward on the glabella. Muscle area 3p is present close to the axial furrow, as in *Ampyx,* and situated a short distance behind the anterior pit. On the axis of the pygidium only one pair of muscle areas, the larger outer pair, is present in the ring furrows. The type species appears to be closest to species of *Ampyxina,* but if the presence of alae in the holaspid is regarded as characteristic of *Ampyxina,* then it cannot be placed here, and seems to represent a different group.

AMPYXOIDES SEMICOSTATUS (Billings, 1865)

Plate 12, figures 13-20; Plate 13, figures 1-10, 12

Billings, 1865, p. 297, fig. 287.
Raymond, 1925, pp. 31-32, pl. 1, figs. 14, 15.

Lectotype (here selected). GSC 690, internal mould of pygidium from Daniel's Harbour. Paralectotypes include two similar pygidia, GSC 690a, 690b, from same locality.

Other material. GSC 693d, cranidium, placed by Billings in *Ampyx laeviusculus.* In the type section of the Table Head Formation this species is the third most abundant, occurring from 90 feet above the base to the top of the middle portion. Topotype material was collected from boulders at Daniel's

Harbour, at Table Cove, in the isolated limestone, and from bed 4 at Black Cove. YPM 13029, Dominion Iron and Steel Co. quarry, Aguathuna, Port au Port peninsula.

Description. Glabella expanding forward to maximum width close to anterior margin, moderately convex (sag. and tr.), frontal spine arising at upper edge of frontal slope, square in cross-section, extending forward horizontally, becoming rounded distally and turning gently upward. Occipital ring narrow, convex, shallow occipital furrow, elongate muscle area at outer end. A short distance in front of occipital furrow and a short distance in from the axial furrow is a small, circular depression, the outer part of glabellar furrow 1p, the remainder visible in some specimens (Pl. 12, fig. 20) as a dark area of the exoskeleton extending in a subcircular muscle area half way up the side of the glabella. Lateral furrow 2p situated a short distance in front of 1p, represented by a shallower subcircular depression situated a short distance in from the axial furrow. In occasional specimens (Pl. 12, fig. 20; Pl. 13, fig. 3) the entire muscle area is revealed as pear-shaped, extending far upward on the side of the glabella. Lateral furrow 3p represented by the dark, circular patch seen in the same specimens, situated close to the axial furrow and just behind the maximum width. Lateral furrow 4p, rarely visible (Pl. 12, fig. 20), is similar and situated at the maximum width, close to the anterior pit. Gently convex cheek sloping outward to narrow, rolled anterior and lateral border. These borders extended beneath the exoskeleton as the narrow doublure which is gently convex ventrally (Pl. 13, fig. 8). Posterior border well defined, narrow proximally and broadening outward, posterior border furrow ending distally in elongate pit. Cheek continued in front of glabella by narrow preglabellar field which diminishes and disappears before reaching the midline. Facial suture runs along border anteriorly, anterolaterally and laterally running just inside the border of the cheek in a course which is slightly sigmoidal, there being a concavity in the course just in front of the genal angle. Free cheek extremely narrow, poorly preserved, but apparently having the narrow border, which is extended posterolaterally as a long genal spine reaching back far beyond the pygidium (Pl. 13, fig. 1).

Thorax of five segments, axis tapering slightly back, first segment markedly longer (sag. and exs.) than those following, the succeeding four segments progressively shorter backward. Axial ring gently convex, articulating furrow with deep pit distally. Pleural furrow of first segment runs from axial furrow in a curve that is at first convex forward, then runs out diagonally in a gentle curve that is concave forward. Pleural furrow of remaining segments straight, slightly diagonally directed. At fulcrum tips of pleurae bent down vertically. Pygidium with prominent axis that tapers back to narrow tip, articulating furrow and first four ring furrows defined on external surface, additional rings on internal mould. Pleural regions extend out horizontally to narrow rim and then are bent down vertically in broad (sag. and exs.) border. First pleural furrow deep and continuous, running slightly diagonally, and with a faint curvature that is concave forward, out to rim. Four additional pleural furrows are faintly indicated on the inner part of the pleural regions, but become deep and distinct distally. Thus the inner part of the pleural region behind the first segment is hardly at all divided. On the external surface of some specimens there are extremely faint interpleural furrows.

External surface of exoskeleton smooth, fine terrace lines on angles of frontal glabellar spine, borders and doublure. On pygidium paired dark spots (muscle areas) are prominent in some specimens (Pl. 12, fig. 18) in the articulating furrow and succeeding four ring furrows. Additional pairs visible as much fainter, smaller spots, closer together and extending back along the tip of the axis on to the upper edge of the border. On the cheek lobe in some specimens the internal mould shows extremely faint genal ridges which run out from the midlength of the glabella toward the posterolateral part of the cheek. Most prominent is the ridge which runs directly toward the genal angle. These lines are extremely faint or absent in some specimens, and do not appear to be visible on the external surface.

Discussion. This species is particularly characteristic of the fine-grained, dark, muddy limestones, but does occur in more coarsely grained, less muddy lime sands. Raymond described the frontal glabellar spine as circular in section, but it appears that he was in error. The present specimens do not show the free cheek well, but reveal the length and curvature of the genal spine.

Genus ANISONOTELLA Whittington, 1952

ANISONOTELLA GLACIALIS (Billings, 1865)

Plate 13, figures 9, 11, 13; Plate 14, figures 1-6, 8

Billings, 1865, p. 283, fig. 270; p. 296.
Raymond, 1920, pp. 279-280.

Raymond, 1925, pp. 44-46, pl. 2, fig. 17.
Whittington, 1952, pp. 4-5.
Whittington *in* Moore 1959, pp. O426-7, fig. 327, 5.

Lectotype (here selected). GSC 670c, cranidium. Paralectotypes include GSC 670, 670a, b, all cranidia, in dark limestone with *Triarthrus fischeri* and *Geragnostus fabius.* The accompanying label reads "Portland Creek and Pistolet Bay" but only 670a has Pistolet Bay written on the back of the specimen. Possibly the lectotype, 670, and 670b are from boulders in Cow Head Group conglomerates near Portland Creek.

Other material. GSC 691, holotype of "*Ampyx*" *rutilius* Billings, 1865, p. 296, from "four miles northeast of Portland Creek," that is, Daniel's Harbour. MCZ 1594, original of Raymond, 1925, pl. 2, fig. 17, from collection of Jules Marcou, from "east side of Port-au-Port," that is, probably bed 4 at Black Cove. The present investigation shows that the species is fairly common in bed 4 at Black Cove and in boulders at Daniel's Harbour.

Description. This species was fully described by Raymond, and the following notes amplify his description. Lateral glabular furrows 1p and 2p are circular in outline and deep, 3p shallower, and there is a faint longitudinal furrow joining these furrows and extending back to the extremity of the occipital ring. The lateral part of the glabella outside this longitudinal furrow is slightly inflated. On the outer edge it is bounded by the narrow alar furrow, outside which is the low, broad ala which extends forward as far as the genal ridge. Outside the ala is the broad shallow axial furrow. Posteriorly the ala is separated from the occipital ring by a shallow extension of the posterior border furrow. A cranidium (Pl. 14, figs. 3, 5, 6, 8) shows the course of the facial sutures, and one almost complete exoskeleton preserves parts of the free cheeks (Pl. 14, figs. 1, 2, 4). Laterally and anterolaterally there is a narrow convex border, separated from the cheek by a shallow border furrow. Anteriorly, the same border furrow and the upper part of the border are visible on the cranidium, so evidently the cephalon possessed a narrow border, though it is broken away anteriorly in the complete specimen. The semicircular backward prolongation of the posterior border (lapet of Raymond) is bounded by the facial suture which then runs forward and inward along the outermost part of the cheek to reach the border furrow in line with the axial furrow, and then crosses the upper surface of the anterior border. The connective suture joins these branches along the anterior edge of the border. The cheek is thus narrow (tr.), but includes the outermost part of the prolongation of the cheek and bears a long genal spine which curves gently outward and reaches back far beyond the pygidium. The genal ridge (eye line of Raymond) commences in the axial furrow opposite lateral glabellar furrow 3p, and is most pronounced proximally; distally it curves outward and backward to run on to the outer edge of the prolongation of the fixed cheek. The cheek behind the genal ridge is inflated, and at and immediately in front of the proximal part of the genal ridge the cheek is depressed.

Pleural furrows of thorax and pygidium broad and well defined, those of thorax, particularly the anterior four, running in a curve that is convex forward. On the axis of the pygidium, up to 11 rings are demarcated, on the pleural region 9 pleural furrows; these furrows flexed back distally. On the anterior four flat pleural ribs faint interpleural furrows may be visible.

On the external surface of the median and frontal glabellar lobes is a pattern of fine, raised anastomising lines. These lines are roughly concentrically arranged with reference to the area they cover, and center around the low median tubercle which is situated in line with lateral furrows 3p. Similar lines are absent from the lateral parts of the glabella, the furrows and the alae, but are present on the cheeks and preglabellar field inside the border. On the inner part of the cheek, behind the genal ridge, the lines run subparallel in curves convex forward, outside this ridge and on the preglabellar field the lines run subparallel to the border furrow.

Discussion. The reconstruction (Whittington, *in* Moore, 1959, fig. 327, 5) is based on the original of Plate 14, figures 1, 2, 4. It shows the branch of the facial suture cutting across the anterior border at a point much farther out than is correct — this crossing occurs at a point roughly in line with the anterior part of the axial furrow. The lines on the external surface of the cephalon were omitted. Raymond (1925, pp. 46-47) suggested that "*Ampyx*" *hornei* (Reed, 1903, pp. 19-21, pl. 3, figs. 8-10) and *Ampyx obtusus* Moberg and Segerberg, 1906 (pp. 100-101, pl. 7, figs. 8-10; Tjernvik, 1956, pp. 271-272, pl. 11, figs. 16-18) were species of *Anisonotella*. Neither of these species appears to belong to this genus; the former may well be a species of *Edmundsonia* Cooper, 1953; the latter is retained in *Ampyx* by Tjernvik. Thus the genus *Anisonotella* is so far known only from the middle Table Head Formation, from few localities and apparently a limited stratigraphical horizon. Billings (1865, p. 296) did not figure his species "*Ampyx*" *rutilius*, but there is no doubt that the holotype (Pl. 13, fig. 9) belongs to *A. glacialis*, and additional pygidia and cranidia have been recovered from the locality.

Raymond (1925) regarded *Anisonotella* as belonging within the family Endymioniidae, but because of the presence of alae and of 3 pairs of glabellar furrows, and the large number of segments in the pygidium, it seems more likely that it belongs within the Raphiophoridae. This is particularly true if the genus *Salteria* is removed from the Endymioniidae (Whittington, 1959, p. 492) leaving this family centered around the peculiar genus *Endymionia*.

Family ENDYMIONIIDAE Raymond, 1920

Genus Endymionia Billings, 1865

Endymionia schucherti Raymond, 1920

Plate 15, figures 1-18, 20

Raymond, 1920, pp. 277-278.
Raymond, 1925, pp. 43-44, pl. 2, fig. 13.

Lectotype (here selected). YPM 13040, cranidium, original of Raymond, 1925, pl. 2, fig. 13, type section, middle Table Head Formation.

Other material. YPM 23856, poorly preserved entire specimen, mentioned by Raymond. Moderately abundant in the type section, from 190 to 215 feet above the base. It also occurs in the highest beds exposed on the foreshore immediately south of Table Cove, and at Daniel's Harbour.

Description. Raymond's description may be amplified and emended as follows. There is a tubercle on the midline of the glabella immediately in front of the occipital furrow (Pl. 15, fig. 6). One or two specimens show a faint tubercle at about the midlength of the glabella. The triangular fixed cheek slopes steeply laterally, bounded by the slightly sinuous, diagonally-directed suture. The posterior border is broad, the posterior border furrow shallow adjacent to the axial furrow, but deepening as it curves outward, and deepest where it curves back distally. Cheek in front of outermost part of border furrow slightly inflated. Suture curves around extremity of border furrow and inward and backward across posterior border.

Cheeks united in front of glabella by gently convex, steeply sloping preglabellar field. Anterior border horizontally directed, narrow (sag. and exs.), bounded laterally by the suture so that the width (tr.) is less than the maximum width of the glabella. Free cheeks unknown.

Thorax of 7 segments, the segments successively shorter (sag. and exs.) backward, the axis tapering only at the last two segments. Pleura crossed by diagonally directed, deep pleural furrow which curves concavely forward. Posterior pleural band gently inflated, most strongly so adjacent to the axial furrow. Pygidium short (sag.), with rapidly tapering axis on which four rings and a small terminal portion are marked out. Horizontal pleural regions crossed by four pleural furrows which are straight and directed successively more strongly backward. Border of pygidium steeply sloping, with narrow rim at upper and lower edges. External surface of exoskeleton smooth except for fine terrace lines on border of pygidium. On preglabellar field a faint pair of tubercles (Pl. 15, fig. 2).

A size series of cranidia ranges from length (sag.) 0.65 mm to 6.5 mm. In the smallest specimen (Pl. 15, figs. 14, 15, 20) the narrow occipital ring is depressed, the glabella in front of it inflated and subparallel-sided, expanding slightly forward to a maximum width across the frontal lobe. Immediately in front of the occipital ring is a low tubercle. The axial furrow beside the glabella is broad, and there is a faint swelling extending forward from the outer end of the occipital ring part way along this furrow. Posterior border furrow of cheek is present on outer slope only, on steeply sloping preglabellar field a conspicuous pair of tubercles. In the next largest cranidium (Pl. 15, figs. 11, 12, 16) the glabella is longer than wide, but the ''lateral lobes'' are conspicuously developed and extend from immediately in front of the outer end of the occipital ring to a point just behind the frontal lobe, and are relatively narrower (tr.) than in larger specimens. The posterior border furrow extends farther inward but is faint proximally. In successively larger cranidia the glabella is of about the same length as width, and the ''lateral lobes'' become relatively wider, especially posteriorly, and increase slightly in convexity. The ''lateral glabellar lobes'' thus appear to originate in the axial furrow beside the glabella, like the alae of raphiophorids and trinucleids (Whittington, 1959, pp. 464-465). However, the alae in these latter families do not become larger and more inflated as size increases, as lateral glabellar lobes do in many non-trinucleid trilobites. The ''lateral glabellar lobes'' in *Endymionia* develop in an unusual way and whether or not they correspond with these lobes in other trilobites is uncertain. The pair of tubercles on the preglabellar field is most conspicuous in the early stages, but is still present in the largest holaspides.

Discussion. The holotype and only known specimen of the type species of *Endymionia, E. meeki* (Billings, 1862, pp. 94-95, fig. 84; 1865, p. 281; this paper, Pl. 15, figs. 19, 23, 24; Pl. 68, figs. 4, 5) came from''the upper part of limestone No. 2,'' Point Lévis, Quebec, that is, from a limestone boulder in one of the conglomerates in the Lévis Shale. It is clear that *E. meeki* is closely related to *E. schucherti*, but differs from the latter species in minor details of the shape and lobation of the glabella, in that the posterior border furrow runs in a curve concave forward, and in that the course of the suture on the outer part of the cheek is more strongly incurved. The median tubercle situated at the midlength of the glabella is conspicuous, and there is no sign of a median tubercle immediately in front of the occipital furrow. Also distinctive of *E. meeki* is the very deep border of the pygidium posteriorly, on to the upper part of which the axis extends (Pl. 68, fig. 5).

Raymond (1914, p. 526; 1925, pp. 42-4) identified certain specimens from the Shumardia Limestone as *E. meeki.* His remarks on this species, and comments on the differences between *meeki* and *schucherti* are based on these specimens, and his original is here refigured (Pl. 15, figs. 21, 22, 25). Additional material obtained by Clark (1924, p. 60) includes MCZ 1961, 1962, 1964. The glabella of this species appears relatively narrower (tr.) than that of *E. meeki*, the posterior border and border furrow are similar in the two species, but they are distinguished readily by the preglabellar field, which in Raymond's specimen slopes steeply downward, is traversed by anastomosing terrace lines, and there is an extremely narrow (tr.), median, horizontally-sloping border. The suture limits this preglabellar area laterally, and the two branches approach quite closely before running on to the narrow horizontal border. In *E. meeki* the two branches are much farther apart (compare figs. 19 and 22, Pl. 15) where they run on to the horizontal border, which is consequently wider (tr.). Because of these differences I propose that Raymond's specimen, and those obtained by Clark, be considered to represent a new species, *Endymionia raymondi* n. sp., holotype MCZ 1963.

From bed 4 at "Black Cove" comes a single specimen (Pl. 14, fig. 7) that is similar to *E. schucherti*. It is flattened and of about twice the size of specimens from other localities. The glabella appears relatively longer than in *schucherti*, and the anterior border of the cranidium also wider (sag. and exs.). The pygidium has the same number of segments in it as large specimens of *E. schucherti*, but is relatively much longer (sag.). Whether these differences are the result of the flattening that the exoskelton has undergone is uncertain.

Family SHUMARDIIDAE Lake, 1907

Genus SHUMARDIA Billings, 1862

SHUMARDIA GRANULOSA Billings, 1862

Plate 16

Billings, 1862, pp. 92-93, fig. 83.
Clark, 1924, pp. 88-89, pl. 9, figs. 1-6.

Lectotype (here selected). GSC 880, incomplete cranidium, on same slab as syntype incomplete pygidium; also on slab are external moulds of two cranidia and one pygidium; Point Lévis, Quebec.

Other material. Museum of Comparative Zoology collections obtained by P. E. Raymond and T. H. Clark are from Lévis, Quebec, presumably largely from Clark's (1924, p. 101) locality D where the Shumardia Limestone is exposed. This limestone is in Raymond's (1914, p. 528) zone D1, which is of early Llanvirn age (Bulman, 1958, p. 166).

Description. Convex cephalon subsemicircular in outline, glabella occupying about one-third the width. Posterior part of glabella semicylindrical in form, anterior part expanded and transversely ovate. A straight occipital furrow isolates the convex occipital ring. Midway between the occipital furrow and anterolateral lobe the glabella adjacent to the axial furrow is deeply indented, and lateral furrow 1p runs inward and backward a short distance from this indentation, and isolates a tiny, circular basal lateral lobe (Pl. 16, figs. 12, 15). Lateral furrow 2p runs forward and inward from the same indentation, becoming progressively shallower but outlining the oval anterolateral lobe, which is of about the same width (tr.) as the intervening frontomedian lobe. Axial furrow is deep beside posterior half of glabella; as it curves forwards around the anterolateral lobe it becomes shallower, and is confluent with the preglabellar furrow, this furrow being V-shaped in outline in anterior view. Cheek convex, sloping vertically distally, and merging anteriorly with the narrow preglabellar area. Latter divided by deep, longitudinal median depression. The cheek slopes inwards to the deep posterior part of the axial furrow, and vertically down to the posterior border furrow. Latter runs straight outward from midpoint of occipital ring, dying out on the steep distal slope of the cheek, and defining a narrow posterior border which lies well below the inner part of the cheek and widens outward. At margin of cheeks and preglabellar area is a narrow ridge; the exoskeleton then curves under to form the doublure, and is apparently traversed by additional ridges. Facial suture runs from genal angle across outer part of cheek and on to marginal ridge of preglabellar area, isolating the free cheeks which are widest (tr.) anterolaterally (Pl. 16, figs. 7, 9, 17). It is uncertain whether or not there is a median ventral suture, and the nature of the genal angle is also unknown. Posterolaterally, the suture curves around inward to the posterior margin, so that the posterolateral angle of the cranidium is rounded. The lectotype is exfoliated, and along the margin of the left cheek runs a broad, shallow furrow, outside which the slope of the cheek is continued for a short distance (Pl. 16, fig. 3). This outermost part of the specimen may be the mould of the doublure, but the form of the doublure is uncertain. External surface granulate except in furrows.

Thorax apparently of six segments. The complete specimen (Pl. 16, figs. 5-7) shows five segments clearly, and what appears to be the first segment lies at a sharp angle to the others and was evidently pushed beneath the most posterior part of the cephalon, and only a small portion of the left pleurae is now visible. Axis broad, convex, pleurae curved downward to slope vertically distally, broadly facetted. There is no evidence on the right side of the complete specimen, where the pleurae are best preserved, that the pleura of the fourth segment was prolonged by the pleural spine as in *Shumardia pusilla* (Stubblefield, 1926, pl. 14, fig. 9). The course of the narrow pleural furrow is unusual, for it leaves the axial furrow close to the posterior margin and runs directly outward, dying out close to the inner edge of the facet. Thus the anterior pleural band is broad (exs.) and convex, the posterior band narrow, widening distally where the pleura curves slightly back. Pygidium triangular in outline, axis tapering rapidly to blunt point, pleural regions prolonged behind axis in a rounded, flattened tip. Axis in largest individual (Pl. 16, fig. 16) divided by furrows into seven rings, which are successively shorter posteriorly, the seventh merely the small posterior tip of the axis. Pleural regions exhibiting four pairs of furrows, the first extending out to the inner edge of the facet, the next three successively shorter so that the fourth is merely a short indentation beside the axial furrow. Narrow posterior pleural band defined on first segment only. External surface granulate except in furrows, the granules becoming smaller, fainter, and dying out on the distal parts of the pleural regions.

Small cranidia (Pl. 16, figs. 1-4, 12, 15) have the two pairs of lateral glabellar lobes better defined, the axial furrows are deep, as also is the median depression in the preglabellar area. The latter bears a pair of tubercles, each in line (exs.) with the midpoint of the anterolateral glabellar lobe. Granulation is coarser and prominent on glabella and inner part of cheek. Small pygidia (Pl. 16, figs. 10, 11, 13) show five segments, the posterior pleural band defined in each, those of the fifth segment running back from the tip of the axis and converging. The tip of the pleural regions is drawn out into a blunt, horizontally-directed point. Granulation is relatively coarser.

Discussion. The single complete specimen is the original of Clark (1924, pl. 9, fig. 3) and I found upon excavation that it was indeed a complete exoskeleton, the cephalon being flexed down at right angles to the thorax and pygidium. As explained above, apparently the first thoracic segment is similarly flexed down, and almost entirely hidden beneath the posterior part of the cephalon. The latter is incomplete, especially at the genal angle, so it is uncertain whether or not there was a genal spine. This specimen is unusual in showing clearly the presence of the suture line running around the distal part of the cheeks and preglabellar area, isolating the narrow free cheeks. Unfortunately it is damaged medially, and one cannot be sure whether or not there was a median suture. This specimen shows that previously described ''cephala'' are in reality cranidia. Raw (*in* Lake, 1907, p. 41) describes the cephalon of *S. pusilla* as ''without free cheeks'' but Lake's plate 4, figure 1, shows the doublure of an enrolled specimen surrounding the pygidium and there is a median feature which may be a crack but may also be a median suture. Further study of European material is needed to determine whether or not, for example, *S. pusilla* (Lake, 1907, pl. 3, figs. 18-20; pl. 4, figs. 1-4; Stubblefield, 1926; Størmer, 1940, pl. 1, fig. 13) should properly be referred to *Shumardia.* The cranidium appears to have the same general form, and the pleurae to be crossed by a pleural furrow which runs close to the posterior margin. However, *S. granulosa* does not have the long pleural spine on the fourth thoracic segment, and the pygidium is very different in shape. Cranidia described as *S. minutula* by Harrington and Leanza (1957, pp. 79-80, figs. 24, 1a, 1c, 1e) look similar to those of *S. granulosa*, though the pygidium attributed to this species by them (fig. 24, 1b) appears to be much shorter and broader than that of the Canadian species.

SHUMARDIA SAGITTULA n. sp.

Plate 17, figures 1-8, 11, 12

Holotype. GSC 18448, cranidium from highest beds of middle Table Head Formation exposed immediately south of Table Cove.

Other material. Cranidia have been obtained from the upper half of the middle Table Head Formation at the type section, from the isolated limestone, and from the boulders at Daniel's Harbour.

Description. These cranidia, when compared with cranidia of a similar size of *S. granulosa* (Pl. 16, figs. 12, 15), may be seen to represent a distinct species. The prominent occipital ring of the glabella is trapezoidal in outline, and bears a faint median tubercle. In front of the straight occipital furrow is a short subcylindrical part of the glabella, then the glabella expands abruptly into the large lateral lobes which are situated at about the midlength. In front of these lobes the axial furrows converge, becoming subparallel as they approach the anterior margin of the cranidium, but not joined by any preglabellar furrow. The slope of the anterior part of the cranidium is less steep than that in *S. granulosa*, and outside the anterior part of the axial furrow on the cheek is the small tubercle. The basal glabellar lobe is apparently not present, and the furrow outlining the anterior lateral lobe runs directly forward and dies out opposite about half the length of this lobe. The cheek is similar in form to that of *S. granulosa*, but there is no posterior border furrow.

Genus LEIOSHUMARDIA n. gen.

Type species. Leioshumardia minima n. gen. n. sp.

Diagnosis. Glabella widest posteriorly, occipital ring outlined by narrow occipital furrow which curves gently convexly forward. Midpart of glabella parallel-sided, of same width (tr.)

as occipital ring, anterior part tapering, defined by axial furrows that converge at an oblique angle and die out before meeting in the median line. No lateral furrows or lobes. Cheeks slope vertically distally, anteriorly continuous with narrow (sag.), steep preglabellar area. Posterior border furrow outlining extremely narrow border on inner part of fixed cheek.

LEIOSHUMARDIA MINIMA n. gen., n. sp.
Plate 17, figures 9, 10, 13, 15-17

Holotype. GSC 18450, cranidium from middle Table Head Formation, exposures on foreshore south of Table Cove.

Other material. A few additional cranidia have been obtained from the same locality as the holotype, and also from 17 and 190 feet above the base of the middle Table Head Formation at the type section.

Description. The diagnosis indicates the chief characters of this cranidium, and in the small example, as in the large, there is no sign of lateral glabellar furrows or lobes. The axial furrow is deep beside the posterior half of the glabella, and widest immediately in front of the occipital furrow; the anterior part becomes progressively shallower forwards, and the furrows appear to die out before intersecting. No pair of tubercles on the preglabellar area. External surface smooth. Remainder of exoskeleton unknown.

Family OLENIDAE Burmeister, 1843

Subfamily OLENINAE Burmeister, 1843

Genus TRIARTHRUS Green, 1832

TRIARTHRUS FISCHERI Billings, 1865
Plate 17, figures 14, 18-21; Plate 18, figures 1-9, 12-16

Billings, 1865, p. 291, fig. 280.
Raymond, 1925, pp. 51-52.

Lectotype (here selected). GSC 678c, the smaller and more complete of two cranidia in the same piece of limestone, from middle Table Head Formation, Pistolet Bay. Paralectotypes: GSC 678d, cranidium and seven thoracic segments; 678h, incomplete cephalon; 678a, b, e, f, g, i, cranidia. All from same horizon and locality as lectotype.

Other material. Type section, middle Table Head Formation, from 90 feet above the base to the top, from Table Cove, the isolated limestone, bed 4 at Black Cove, and from boulders at Daniel's Harbour.

Description. Cephalon wider than long, moderately convex. Maximum width of glabella two-thirds that of cephalon at posterior border. Glabella of width about equal to length (sag.), maximum width across basal glabellar lobes. Occipital ring widest (sag.) medially, becoming narrower and curving forward distally; occipital furrow deep behind glabellar lobes, shallower medially. Two pairs of lateral glabellar furrows gently curved, directed inward and slightly backward. Frontal glabellar lobe longer than first and second, lateral lobes 1p and 2p of similar width (tr.), median lobe narrower than lateral lobes. Lateral lobe 1p gently inflated, frontal glabellar lobe rounded anteriorly, minimum width of glabella at anterior edge of this lobe. Lateral glabellar furrow 3p visible on some of larger cranidia (Pl. 18, figs. 1, 3) as a small, shallow pit situated in line within the inner ends of lateral furrows 1p and 2p, these three furrows situated at approximately equal distances from each other and the occipital furrow. Anterior pit situated in axial furrow a short distance back from anterior end, preglabellar furrow broader than axial, narrow, anterior border which in dorsal aspect is moderately curved. About 12 shallow pits are equally spaced along preglabellar furrow. Narrow cheek curved downward quite steeply distally, narrow, convex posterior and lateral borders similar to anterior border, defined by shallow border furrows. Midpoint of eye lobe situated opposite outer end of lateral glabellar furrow 2p, and about half way out across cheek. Low eye ridge runs inward and forward to axial furrow opposite anterior pit. Anterior branch of suture runs forward and slightly inward to border, curves over it and runs along outer edge. Posterior branch runs backward in the same line as the anterior branch, near posterior border curving slightly inward and across border. Free cheek (Pl. 18, fig. 7) thus narrow (tr.), and suture crosses broadly rounded genal angle which does not bear a spine. Similar pits to those in preglabellar furrow situated in border furrow of fixed cheek. Doublure of cephalon of similar width to borders, curled under to make a cylindrical border (Pl. 17, fig. 18). Hypostome unknown.

Thorax (Pl. 17, figs. 20, 21) of at least 14 segments, axis about one-third of total width, tapering gently backward, moderately convex. Articulating half ring about half length (sag.) of axial ring, articulating furrow deepened distally. Each pleura directed outward and slightly back, fulcrum at about one-third width of axial furrow, outer part bent quite steeply downward. Deep pleural furrow extends from inner anterior corner to tip. Anterolateral margin of pleura facetted, posterolateral corner bluntly pointed. Small pygidium with four distinct axial rings, the first the most prominent, tip of axis showing a faintly defined 5th ring, bluntly rounded. Pleural regions exhibiting the articulating facet and three ribs, separated by pleural furrows which become shallow posteriorly, distal parts becoming smooth.

External surface apparently smooth, small median tubercle situated close to anterior margin of occipital ring. In available specimens midpart of axial rings of thorax are broken, but there is no evidence of a median axial spine.

Discussion. Few specimens are available that show the free cheek in position (Pl. 17, fig. 18; Pl. 18, fig. 7), and in all there has been some displacement, so that details of the eye lobe cannot be made out. The free cheek has a shallow border furrow and convex border, while on the fixed cheek there is a sutural ridge (Pl. 17, fig. 21), that is, a shallow furrow curves forward from the posterior border furrow to run beside the posterior branch of the suture to the palpebral lobe. The faintly convex strip between this furrow and the suture is referred to as the sutural ridge, and is visible in the smallest cranidia (Pl. 18, fig. 16). The material from most localities is not flattened, except a few specimens from Black Cove. The difference in appearance between a flattened cranidium (Pl. 17, fig. 19) and one retaining full convexity (Pl. 17, fig. 20) is notable — in the former the glabella does not appear to be widest across the basal lobes, but to be subsquare in outline, the anterior branches of the facial suture run almost directly forward, and the outline of the anterior margin of the cranidium is almost straight. It is evident that comparisons between specimens which are preserved in these different ways have to be made with caution.

The size series of cranidia, ranging from 0.55 mm (Pl. 18, figs. 15, 16) to approximately 5 mm (Pl. 18, figs. 1-3) in length (sag.), shows clearly changes that take place in the outline and proportions of the glabella. In the smallest cranidium the glabella is longer (sag.) than wide (tr.), and the maximum width is across the frontal lobe. Lateral furrows are straight, directed inward and slightly backward. In a cranidium 1.8 mm in length (Pl. 18, figs. 8, 9) the glabella is parallel-sided, the occipital ring like that of the largest specimens, and the lateral furrows have assumed a slight curvature. With increasing size the glabella continues to become relatively wider (and the cheek to become relatively narrower) and in the larger examples the maximum width is across the basal glabellar lobes, which have become slightly inflated. There is little change in the position of the palpebral lobe, and the eye ridge and sutural ridge are visible in the smallest specimens. These changes during ontogeny are like those that take place in a size series of *Triarthrus eatoni* (Whittington, 1957, pp. 941-943, pl. 116, figs. 1-13).

Species of *Triarthrus* of Tremadoc age (Henningsmoen, 1957, pp. 147-151; Harrington and Leanza, 1957, pp. 113-117, figs. 42; 43, 2) differ from *T. fischeri* generally in possessing the short (sag. and exs.) preglabellar field, though some species exhibit an outline of the glabella similar to that of the Table Head species. Clark (1924, pp. 91-92, pl. 9, fig. 12) described a species *Boeckia? descensus* from the Shumardia Limestone of Lévis, Quebec. Henningsmoen (1957, p. 22) suggested that this species was not an olenid, but restudy of the holotype (Pl. 18, figs. 10, 11) shows that the incomplete cranidium is similar to cranidia of the same size of *T. fischeri* (Pl. 18, figs. 12-14). Thus Clark's species probably does belong within *Triarthrus*, and may represent a form closely related to *T. fischeri.* Bulman (1931, pp. 88-89, pl. 10, figs. 5-8) described *T.* aff. *fischeri* from beds of Llanvirn age in Bolivia, and this species is evidently closely related to that from Newfoundland. A species from the Llanvirn of Britain, *T.* (*sensu lato*) *convergens* Whittard (1961, pp. 190-191, pl. 24, figs. 16-18), appears to differ from *T. fischeri* in the much smaller free cheek and in that the thoracic axis is relatively broad and does not taper for the first six segments, after which it tapers rather rapidly.

Whittard (1961, p. 189, text-fig. 7) also gives new illustrations of *T. caecigenus* from the *N. gracilis* Athens Shale of Virginia. The large palpebral lobe and broad eye ridge of this species distinguishes it at once, as does the extreme shortness of the preglabellar area and the subrectangular outline of the glabella. At least four species of *Triarthrus* — *T. beckii* Green, 1832, *T. eatoni* (Hall, 1838), *T. spinosus* Billings, 1859, *T. glaber* Billings, 1859 — are recognized from dark shales of the Trenton Group of New York and Canada (Ruedemann, 1926; Wilson, 1956; Whittington, 1957). Type and topotype material of these species suggest that in the combination of characters of glabellar outline, relative size of lobes, development of occipital spine, position of eye lobe and size of cheek, no one of the species is the same as *T. fischeri.*

Subfamily HYPERMECASPIDINAE
Harrington and Leanza, 1957

Genus HYPERMECASPIS Harrington and Leanza, 1957

HYPERMECASPIS cf. BULMANI Harrington and Leanza, 1957
Plate 18, figures 17-22

Material. Incomplete cranidium, fragment of glabella, incomplete pygidium, all from middle Table Head Formation at type section. The exact level from which these specimens came is not known, but the fine-grained black limestone is typical of the upper half of this part of the formation, and GSC 18460 also contains *Geragnostus fabius,* which has only been found between 185 and 215 feet above the base of the middle Table Head. GSC 458, a small pygidium, is from the west side of Pistolet Bay.

Description. Glabella subsquare in outline, lateral margin gently bowed outward, anterior margin similarly bowed forward, moderately convex longitudinally and transversely. Occipital ring defined by shallow furrow which curves forward in the outer one-third of its course, subparallel to the posterior margin of the ring. Ring (Pl. 18, fig. 19) subdivided by a transverse furrow running a short distance in front of the posterior margin, medially faint and passing directly behind the small median occipital tubercle. Laterally, a gently convex occipital lobe is defined by a shallow furrow which curves back from the occipital furrow, runs outward subparallel to the furrow in the occipital ring, and dies out without reaching the axial furrow. Four pairs of lateral glabellar furrows (Pl. 18, fig. 17), 1p situated a short distance in front of the occipital furrow, transverse, short and deep. Furrow 2p commences in the axial furrow at the point where the glabella is widest (just behind the midlength), is deep and curves inward and backward. Lateral furrow 3p similar in depth, direction and curvature to 2p. Lateral furrow 4p commences in the axial furrow just behind the anterolateral corner of the glabella, runs at first straight inward, then turns at an oblique angle and runs inward and backward subparallel to the inner part of furrow 3p. The inner ends of furrows 2p to 4p lie in the same exsagittal line, and the median glabellar lobe is much narrower (tr.) than the lateral lobes; inner parts of these three furrows are deeper and broader than the outer parts. Frontal glabellar lobe divided by shallow median furrow which runs inward from preglabellar furrow and dies out just before reaching the posterior margin of the frontal lobe. Preglabellar field narrow (sag. and exs.), gently convex, becoming slightly wider distally. Anterior border narrow, convex, likewise becoming slightly wider (exs.) distally. Anterior part of fixed cheek extremely narrow (tr.), gently convex; beside lateral glabellar lobes 2p and 3p it separates the axial furrow from the palpebral furrow; the midpoint of the poorly preserved palpebral lobe appears to be opposite the outer end of lateral glabellar furrow 2p. Posterior part of fixed cheek of about the same width (tr.) as glabella, curving gently outward and downward, subdivided by broad, shallow, posterior border furrow which runs from beside lateral occipital lobe outward and slightly forward to die out distally. Remainder of cephalon not known.

Pygidium subdiamond-shaped in outline, moderately convex, axis tapering rapidly to about the midlength, beyond this point specimen poorly preserved and outline of axis uncertain. On anterior half of axis five rings defined by shallow ring furrows. Pleural regions crossed by five pleural furrows, the low rib between them crossed by faint interpleural furrow on the first four segments. Distally, pleural furrows die out and outer margin of pleural region appears smooth.

Discussion. These specimens appear most like the cranidium and pygidium described from the Llanvirn of Bolivia by Bulman (1931, pp. 90-91, pl. 11, figs. 4, 5), which were placed in the genus *Hypermecaspis* by Harrington and Leanza (1957, pp. 121-123) and given the new specific name *bulmani*. Allowing for the compression of the Bolivian material, the glabellar shape and lobation appears extremely similar, likewise the pygidium, except that the latter shows a sixth pleural furrow. Of the species described by Harrington and Leanza from Argentina, the Newfoundland material is most like the type species of the genus *H. inermis* Harrington and Leanza (1957, pp. 121-125, figs. 45; 46, 1-7; 48, 6). There is some difference in the glabellar lobation, in that in the Argentine species, lateral furrow 2p branches and does not extend to the axial furrow, and the most anterior furrow is divided into two parts, referred to as the fourth and fifth furrows by Harrington and Leanza. Possibly the two parts of lateral furrow 4p in the Newfoundland specimen, which are placed at an oblique angle to each other, represent these two furrows in *H. inermis*. This latter species has a large pygidium, which is quite like that from Newfoundland.

The other species from the Argentine are distinguished by possessing a longer preglabellar field and a small pygidium.

Harrington and Leanza (1957, pp. 120-121) erected the family Hypermecaspididae, but Henningsmoen (1959, pp. 160-161) considered it more likely that this group should be a subfamily of the Olenidae. This suggestion is followed here.

Family PROETIDAE Salter, 1864

Subfamily PROETIDELLINAE Hupé, 1953

Genus PHASEOLOPS Whittington, 1963

PHASEOLOPS ? sp. ind.

Plate 19, figures 1-5

Material. Three incomplete cranidia, two from the isolated limestone, and one from 185 feet above the base of the type section, middle Table Head Formation.

Discussion. This cranidium appears to be that of a proetid, and resembles that of the type and only known species of *Phaseolops* (Whittington, 1963, pp. 36-40, pl. 4, figs. 11-13; pl. 5, figs. 1-6). It differs from *P. sepositus* in a number of characters. The glabella tapers forward much more rapidly to the bluntly rounded frontal lobe, the occipital ring is much narrower (exs.) distally, the median occipital tubercle is situated close to the anterior margin. Lateral glabellar furrow 1p is continued backward by a faint furrow that reaches the occipital furrow and isolates the subtriangular basal glabellar lobe. Lateral furrow 2p is diagonally directed, subparallel to the outer part of 1p, lateral furrow 3p is exceedingly faint. There is a broad preglabellar field which slopes downward and forward, but the anterior border is flat and horizontally extended, not convex. Palpebral lobe is situated opposite lateral glabellar lobe 2p, and separated by a narrow convex band of the fixed cheek from the axial furrow; the lobe is gently convex and outlined by a faint furrow. The course of the anterior branches of the facial suture is not well preserved, but they appear to be almost straight and divergent, not strongly curved as in *P. sepositus* and less strongly divergent. Hardly any of the fixed cheek behind the palpebral lobe is preserved, but it appears to be gently convex, and the posterior branch of the suture appears to run outward and backward from the lobe. The appearance is not the same as in *P. sepositus,* for in that species the posterior branch of the suture appears to run at first directly back from the palpebral lobe, before curving outward, and there is only a very small area of cheek between this suture and the axial and border furrows, not the much larger area seen in one specimen of the present species (Pl. 19, fig. 1). External surface is minutely granular.

This rare cranidium may belong to *Phaseolops,* and does not particularly resemble other Ordovician proetids.

A transitory pygidium from the middle Table Head Formation (Pl. 67, fig. 14) has the axis tapering rapidly to a blunt point, is divided by ring furrows into six rings, the tip situated at about two-thirds the length. On the pleural regions six segments are present, the pleural furrows deep, interpleural furrows shallower, and the convex posterior pleural bands of the fifth and sixth segments running outward and backward from the tip of the axis. This transitory pygidium is proetid-like in appearance, and not like that of *Raymondaspis reticulatus* n. sp. (compare Pl. 67, fig. 14 with Pl. 57, figs. 10, 11) in that the pleural furrows are more strongly marked. It is tentatively assigned to *Phaseolops?* sp. ind.

Family DIMEROPYGIDAE Hupé, 1953

Genus ISCHYROTOMA Raymond, 1925

ISCHYROTOMA sp. ind.

Plate 19, figures 17, 21, 22

Material. One incomplete and partly exfoliated cranidium from exposures on foreshore south of Table Cove.

Description. In shape and convexity of the cephalon, form of the glabella with the faint lateral depressions representing furrows 1p and 2p, convex cephalic border which arches upward medially, this cephalon is like that of the type species *I. twenhofeli* Raymond (Whittington, 1963, pp. 45-48, pl. 7). However, it does not appear identical with that species in that the glabella is less tumid, the frontal lobe is blunter and more square-ended, and the posterior branch of the suture runs much more strongly outward across the cheek. This latter character seems to indicate that the eye lobe is placed much further back, though it is not preserved. The lateral border furrow is wider and more prominent in the Table Head cranidium. Tuberculation on the external surface appears to be similar, and there is a notably large tubercle at the inner corner of the fixed cheek and on the posterior border in line (exs.) with it. Thus the Table

Head species seems not to be identical with that from Lower Head, but the single cranidium is inadequate as a basis for a new species.

Genus ISCHYROPHYMA Whittington, 1963

ISCHYROPHYMA TUMIDA n. sp.

Plate 19, figures 6-12, 15

Holotype. GSC 18465, incomplete internal mould of cranidium, from middle Table Head Formation, Table Cove.

Other material. Cranidia and free cheeks from same locality as holotype, the isolated limestone, and 50 feet above base, type section.

Description. The present material when compared with the type and only known species (Whittington, 1963, pp. 48-50, pl. 8, figs. 1-10) exhibits all the diagnostic features of the genus. The glabella is relatively longer and more inflated, and in lateral profile (compare Pl. 19, figs. 9, 10, with Whittington, 1963, pl. 8, figs. 7, 9) it projects much farther forward in front of the anterior border. There is no preglabellar field, and the anterior border projects outward at the margin of the cranidium, suggesting that the characteristic projection is present. Lateral glabellar furrow 2p is short and appears as a shallow, smooth depression in the internal mould. There is a faint suggestion of lateral furrow 3p as a much shorter and shallower depression adjacent to the axial furrow a short distance in front of 2p. The free cheek exhibits the thorn-like genal spine at the rounded angle, and the external surface is, except in the furrows, covered with medium sized tubercles, between which are scatttered much smaller tubercles. On the lateral border there is no row of tubercles, but several terrace lines run subparallel to the margin. While most of the present material is much larger than any known of the type species, the relatively longer and forwardly projecting glabella distinguishes it, as does the much finer tuberculation on the external surface.

Discussion. Raymond (1925, pp. 151-152) described two cranidia (one from the type section and the other from the isolated limestone) which he referred to *Sphaerexochus desertus* (Billings, 1865). I have examined these cranidia and they are identical with the present material. Billings' (1865, pp. 333-334, fig. 321) species *desertus,* which he referred to *Harpides?*, is based on a glabella from a locality in Quebec (GSC 873) and is different from the present material.

ISCHYROPHYMA ? sp. ind.

Plate 19, figures 16, 19, 20

Material. Two incomplete and exfoliated cranidia, one from the isolated limestone, the other from Table Cove.

Description. The glabella tapers slightly forward, is bluntly rounded anteriorly, and a small basal lobe is formed by the diagonally-directed lateral furrow 1p. Cheek is convex, the outer part sloping steeply, the well-defined posterior border widening outward. Palpebral lobe is situated far back, opposite lateral furrow 1p, and on the highest part of the cheek. The anterior branch of the suture runs forward and slightly inward, the posterior branch at first directly outward, then curving to cross the posterior border furrow and the border. Anterior border is not preserved.

This cranidium is like a cephalon recently described under the same designation (Whittington, 1963, p. 50, pl. 6, figs. 13-15) and seemingly represents the same or a closely related species. The affinities with *Ischyrophyma* are uncertain. The glabella is less tumid, and the cheek slopes less steeply laterally. The main similarity is in the position of the small basal glabellar lobes. The present cranidium also has a superficial resemblance to that here placed in aff. *Calymenidius* (Pl. 59, figs. 14, 15), though the glabella projects relatively farther forward, the eye lobe is situated much farther back and closer to the glabella, and the transverse curvature of the anterior border is not so pronounced.

Family ASAPHIDAE Burmeister, 1843

Subfamily ISOTELINAE Angelin, 1854

Genus STEGNOPSIS n. gen.

Type species. Stegnopsis solitarius n. gen., n. sp.

Diagnosis. Cephalon with preglabellar area of width (sag.) about one-fifth length of cephalon, forming a broad, gently sloping border which narrows progressively as it extends around the cheek to the base of the librigenal spine. Cephalon inside border moderately convex, glabella faintly outlined, constricted between the eye lobes, occipital and lateral furrows barely visible on external surface, faintly visible on internal mould, glabellar tubercle situated a short distance in front of occipital furrow. Eye lobe relatively large, situated close to glabella and length (exs.) equal to, or slightly less than, distance from posterior margin of cephalon to posterior margin of eye lobe. Facial suture isoteliform, anterior branches widely divergent in front of eye lobe. Broad doublure is deeply notched anteriorly and crossed by median suture; doublure extends beneath border and half way up slope toward eye lobe; panderian opening situated at inner posterolateral corner of doublure. Hypostome with subcircular middle body, lateral margin convex outward, posterior border deeply and widely notched. Anterior wing subtriangular with broadly rounded, upwardly-projecting tip.

Thorax unknown. Pygidium with broad, gently sloping border surrounding moderately convex inner portion, axis gently convex and extending to inner margin of border; axial rings faintly visible on internal mould, inner part of pleural region faintly furrowed. Doublure extends in beyond border to an almost straight line linking the midpart of the facet to the tip of the axis, where the margin of the doublure is notched.

Discussion. The work of Jaanusson (1953a, 1953b, 1956, 1959, *in* Moore) and Hintze and Jaanusson (1956) has brought many new characters into play in the discrimination of asaphid genera. Some discussion of these characters is contained in Jaanusson, 1953a (pp. 386-389), and it is clear that poorly known old species, such as many from Canadian and Chazyan rocks of the Appalachians, cannot be fitted into these genera. Species of *Isoteloides* (Hintze and Jaanusson, 1956, pp. 55-56; Jaanusson *in* Moore, 1959, p. O341, fig. 251, 1) may prove to be most closely related to the two species described below. However, the Newfoundland species are distinguished at once from the type species *I. whitfieldi* by the position of the eye lobe, which is much farther back and closer to the glabella. Associated with this difference is the different course of the anterior branch of the suture. Lack of knowledge of the doublure of *I. whitfieldi* precludes discussion of these portions of the exoskeleton. In other features, such as the cephalic and pygidial borders, the strength of furrows in both cephalon and pygidium, *I. whitfieldi* is like the Newfoundland species. Of other Lower Ordovician asaphid genera described by Ross and Hintze from Utah, only *Lachnostoma* Ross, 1951 (pp. 94-97, pl. 21, figs. 13-25; pl. 22, figs. 3, 6-8; pl. 25, figs. 5, 6; Hintze, 1953, p. 187, pl. 18, figs. 14-16) shows a likeness to *S. solitarius* and *S. huttoni,* in the position of the eye lobe and course of the anterior branches of the suture. In other features the Utah species is unlike those from Newfoundland.

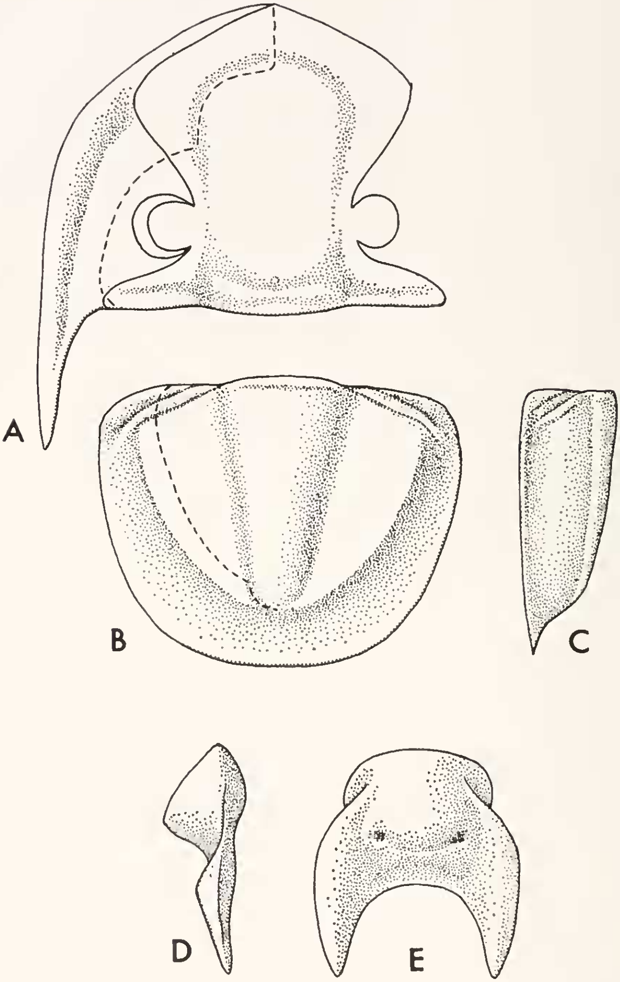

Fig. 3. *Stegnopsis solitarius* n. gen., n. sp., lower Table Head Formation. A, cephalon with right free cheek absent, dorsal view; B, C, pygidium, dorsal, left lateral views; D, E, hypostome, right lateral, exterior views; c. X 1.5. Dotted line shows position of inner margin of doublure. Compare Plate 20; Plate 21, figures 1-4, 6.

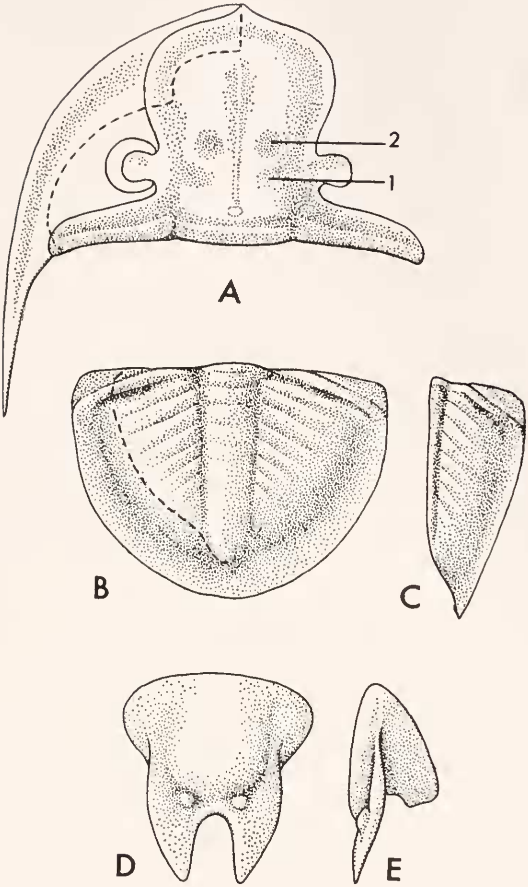

FIG. 4. *Stegnopsis huttoni* (Billings), middle Table Head Formation. A, cephalon lacking right free cheek, dorsal view; B, C, pygidium, dorsal, right lateral views; D, E, hypostome, exterior, left lateral views; X 1.5. 1, 2, muscle areas. Dotted line shows position of inner edge of doublure. Compare Plate 21, figures 5, 7-12; Plate 22, figures 1-7; Plate 23, figures 2-5, 8.

Raymond (1925, p. 81) placed *S. huttoni* in *Megalaspis* and compared it with the species "*M. pagiata*" (presumably an error for *patagiata*), a species which Jaanusson (1953a, pp. 456-459, pl. 9, figs. 4-7; pl. 10, fig. 1, text-fig. 5, 9) placed in *Pseudomegalaspis*. Though there are a number of characters in common between species of *Pseudomegalaspis* and *S. huttoni*, the shorter preglabellar field, lack of concave border of cephalon and pygidium, and form of the pygidial doublure distinguish the former. In a considerable number of characters *S. solitarius* and *S. huttoni* resemble species of *Pseudasaphus* (Jaanusson, 1953a, pp. 417-426; Schmidt, 1904, pp. 4-20). These common characters include shape of glabella, position of eye lobe, presence of cephalic border, width of cephalic doublure, form of hypostome (compare Pl. 20, figs. 4, 8 with Schmidt, pl. 1, figs. 6-8), form of pygidium including presence of border. Distinctive of *Pseudasaphus* are the lateral glabellar furrows 1p, the extremely wide pygidial doublure, and the strong terrace lines of the external surface. Following Jaanusson, I have regarded such differences as of generic rank, though species of *Pseudasaphus* are present in the Baltic Ordovician in rocks older, and contemporaneous with, the Table Head Limestone.

STEGNOPSIS SOLITARIUS n. gen., n. sp.

Plate 20; Plate 21, figures 1-4, 6; Text-figure 3

Asaphus canalis?, Billings, 1865, pp. 270-271, figs. 225a, b.
aff. *Isoteloides* sp., Whittington and Kindle, 1963, fig. 2.

Holotype. GSC 18472, incomplete cranidium with exoskeleton, from lower Table Head Formation, Pointe Riche.

Material. This species is the only asaphid in the lower Table Head, appearing in the type section in bed 2 and ranging up to above the middle of bed 8. Fragments of the exoskeleton appear occasionally, and on weathered surfaces large isolated hypostomes, six or more centimeters in length (exs.) have been found and are like that figured by Billings. The best material came from bed 8 in the type section, and from Pointe Riche.

Description. Cephalon slightly wider than long (sag.), gently convex, border flattened, sloping gently outwardly, widest (sag.) anteriorly, narrowing progressively laterally to a minimum at the base of the short, slim librigenal spine. Glabella of width (tr.) about one-third that of cephalon, extremely faintly outlined by change in slope but not by furrows, not displaying occipital or glabellar furrows, but with median glabellar tubercle situated about one-sixth the length from the posterior margin. Highest point of eye lobe standing level with median part of glabella. Outside eye lobe cheek slopes steeply, in gently convex curve, anterolaterally and laterally, the slope changing to concave as it merges into the outward sloping border. At point of widest divergence anterior branches of suture are as far apart as outer margins of eye lobes. On posterior part of fixed cheek a faint posterior border furrow outlines a posterior border which widens outward. Because of the deep, broad anterior notch, the anterior part of the doublure, which is crossed by the median suture, extends only beneath the border. Posteriorly, close to the inner edge of the doublure where it curves beneath the posterior border, is the panderian opening, situated on a tubercle which appears as a depression in the inner surface of the doublure (Pl. 20, figs. 7, 10). Doublure lies close to dorsal exoskeleton, especially beneath the cheek inside the border.

Hypostome includes a subcircular, gently convex middle body which is indented posterolaterally by the macula. Lateral and posterior borders are broad and long (exs.), with a deep posterior notch the sides of which are strongly divergent. The length (exs.) of the posterolateral prong of the hypostome is such that the length (sag.) of the middle body is only about one-half that of the hypostome. On the ventral surface the prong is approximately flat, the inner edge raised along the margin of the notch. On the dorsal side the doublure is convex, so that the prong is thick at the base and tapers to the tip (Pl. 20, fig. 8). A sharp fold runs from the shoulder around the curving, anterolateral margin of the subcircular middle body, there is no anterior border, and on the dorsal side this fold is extended anterolaterally as the anterior wing, which is subtriangular in shape.

Thorax unknown. Pygidium wider than long, subsemicircular in outline and moderately convex, the lateral and posterior parts of the pleural regions forming a flattened, gently outwardly sloping border which is widest posterolaterally. The middle part of the pygidium is subtriangular in outline and stands high above this border and slopes steeply down to it posterolaterally. The axis tapers gradually and extends to the posterior margin of this central triangular region, and is defined by its slight additional convexity, but not by axial furrows, posterior tip bluntly rounded. In addition to the articulating furrow five or six ring furrows can be observed, most clearly on the internal mould (Pl. 21, fig. 4). Pleural region with a large facet, against which the border ends. The shallow first pleural furrow runs outward and backward to end against the inner edge of this facet. Eight or nine additional pleural furrows are extremely faintly marked on the external surface (and more strongly on the internal mould) of the inner convex part. Doublure extends inward beneath the border and under the concave slope of the outermost part of the convex region. The inner margin is approximately straight, running from about the midpoint of the facet to the tip of the axis.

External surface apparently smooth, except for lateral part of pygidial border and outer part of facet, across which run irregular terrace lines, rather widely spaced. Doublure of both cephalon and pygidium traversed by closely-spaced terrace lines which run parallel to the external margin.

STEGNOPSIS HUTTONI (Billings, 1865)

Plate 21, figures 5, 7-12; Plates 22, 23; Text-figure 4

Billings, 1865, p. 271, fig. 256.
Raymond, 1925, pp. 80-81, pl. 6, fig. 11.
aff. *Lachnostoma huttoni*, Whittington and Kindle, 1963, fig. 3.

Holotype. GSC 657, internal mould of incomplete pygidium, original of Billings, figure 256, from the middle Table Head Formation at the type section.

Other material. GSC 658, small pygidium, from Portland Creek (GSC 658a, b, here referred to *Niobe morrisi;* GSC 658c, d, e, to *Raymondaspis reticulatus* n. sp.). This species appears about 50 feet above the base of the middle Table Head Formation at the type section, and ranges to the top of this part of the formation. It is also present in the exposures south of Table Cove, in the isolated limestone, and pygidia have been found at Black Cove.

Description. At posterior margin, width (tr.)of glabella one-quarter that of cephalon, in front of here glabella narrows slightly to a minimum between the eye lobes, in front of here expanding to the rounded frontal lobe. Glabella gently convex, separated from cheek and preglabellar area by gentle change in slope. On external surface glabellar furrows are not visible, but glabellar tubercle is prominent. Internal moulds and some specimens of the exoskeleton (Pl. 22, figs. 3, 12) show areas of muscle attachment — one at the distal part of the occipital furrow, a second running inward and backward from a point opposite the midlength of the eye lobe. The latter forms lateral furrow 1p; in front of it are two areas which are close to each other, one adjacent to the axial furrow and in line with the most anterior part of the eye lobe, the other between it and the midline. A low ridge runs forward from the glabellar tubercle to the frontal lobe. The visual surface of the eye lobe appears smooth, the minute facets being difficult to discern (Pl. 23, fig. 11). There is no external marginal rim to the eye lobe. The palpebral lobe stands high, level in a transverse line with the midpart of the glabella. The flattened, gently outward-sloping cephalic border is widest anteriorly, narrowing progressively around the cheek and extending on to the outer part of the short, slim librigenal spine. The doublure is pressed closely beneath the dorsal exoskeleton, the inner edge revealed by the paradoublural line (Pl. 22, figs. 1, 2, 7). The position of the panderian opening is shown by the pit situated close to the inner margin of the posterolateral part of the doublure (Pl. 22, fig. 6). The middle body of the hypostome is gently convex, length (sag.) greater than that of forked posterior border. Prominent macula situated in posterolateral part of middle body. Narrow lateral border widens to posterolateral shoulder, posterior border is deeply notched, lateral margin of border convexly curved, inner part of notch narrow. Anterior wing is large, proximally merging with middle body, distally extended upward and backward in a tongue-shaped projection (Pl. 23, figs. 4, 5).

Thorax unknown. Pygidium sub-semicircular in outline, gently sloping posterolateral border, relatively narrow axis tapering to rounded point and reaching inner edge of border. Eight to ten rings are faintly outlined on the axis in internal moulds, on pleural region first furrow is distinct, ending against large facet. Faintly visible on the external surface, and more strongly on internal moulds, are the succeeding eight pleural furrows, the anterior two or three ribs showing extremely faintly the interpleural furrows (Pl. 23, fig. 2). In ventral aspect the doublure is gently convex.

External surface of dorsal exoskeleton appears smooth, but on well-preserved specimens (Pl. 23, fig. 1) the surface is indented by closely spaced, extremely small pits, between which are irregular, short, fine terrace lines. The doublure and hypostome are traversed by terrace lines which run subparallel to the outer margin.

Discussion. In small cranidia (Pl. 22, figs. 9, 11, 13), the glabella is better outlined and relatively more convex, and two depressions are visible, one at the extremity of the occipital furrow, the second forming lateral glabellar furrow 1p. A gently convex basal glabellar lobe is also present, and appears to extend outward on to the cheek beside the posterior part of the large palpebral lobe. The glabellar tubercle is prominent. In small true pygidia (Pl. 21, figs. 9-11) axial and pleural furrows are more prominent, those of the anterior few segments extending to the lateral margin. In transitory pygidia (Pl. 23, figs. 6, 7, 9, 10, 12, 13) all furrows are stronger, and interpleural furrows are present. The notch in the posterior margin behind the axis is peculiar to this developmental stage, and in the smallest example (Pl. 23, figs. 12, 13) pleural ribs run back from the tip of the axis to the sides of the notch. The similarity between these small developmental stages and those attributed to *Isotelus* (Whittington, 1941, pl. 75, figs. 27, 28, 34, 35) and similar asaphids (Evitt, 1961, pl. 117, figs. 20-23) is remarkable.

The cephalon of *S. huttoni* differs from that of *S. solitarius* in the relatively shorter (sag.) preglabellar area, more expanded frontal glabellar lobe, the slightly stronger development of the posterior border furrow, and the quite different form of the hypostome. In *S. solitarius* the hypostome has the middle body much shorter (sag.) than the forked borders, and the outline of the lateral margins of the notch are quite different. The pygidium of *S. solitarius* is distinguished by its relatively greater width, less obvious development of pleural furrows, and relatively wider border.

Subfamily NIOBINAE Jaanusson, 1959

Genus NIOBE Angelin, 1851

Type species. Niobe frontalis (Dalman, 1827).

Discussion. The type species has recently been described by Bohlin (1955, pp. 143-148, pl. 6, figs. 5-9, text-figs. 9a, b) and comes from the *Gigas* Limestone of Sweden, which is of early Llanvirn age (Jaanusson, 1960, Table 9). The cranidium is extremely like that of *N. quadraticaudata*, not only in outline of the glabella and position of the palpebral lobes, but in the size and position of the muscle areas, the alae, and the distribution of terrace lines on the external surface. The hypostome of *N. frontalis* (Jaanusson *in* Moore, 1959, fig. 259, 2c) is much like that of *N. quadraticaudata,* but the pygidium has the inner part of the pleural regions subdivided into ribs, which are rounded and convex at their distal ends, in contrast to the pleural regions of the Newfoundland species, which are grooved only by the first pleural furrow. This relatively slight difference suggests that the Newfoundland species should be placed in *Niobe.*

The genus *Niobella* Reed, 1931 (see Lake, 1942, pp. 329-332, pl. 46, figs. 4-7; 1946, p. 333) is based upon a species from the British Tremadoc in which the hypostome tapers backward and is smoothly rounded. The dorsal exoskeleton is like that of species of *Niobe,* the pleural regions of the pygidium being ribbed. Lake preferred to regard *Niobella* as a subgenus of *Niobe,* but Tjernvik (1956, pp. 223-224) employed two generic groups, distinguishing them primarily on the characters of the pygidium — *Niobe* being used for those species in which the pleural ribs are convex distally and end abruptly, *Niobella* for those forms in which the pleural regions are faintly furrowed or smooth. Species of the former group occur in the Lower and early Middle Ordovician, of the latter in the upper Cambrian and Lower Ordovician, and in both evolution is towards species with a ''frontally expanded glabella, a hypostome with a pair of large, rounded posterior limbs, and a broad pygidial doublure'' (Tjernvik, 1956, p. 228). Jaanusson (1959, *in* Moore, p. O350) followed Tjernvik, but I do not find this single-character grouping satisfactory. It means that *quadraticaudata* must be excluded from *Niobe,* and both it and *morrisi* placed in *Niobella,* despite the different hypostome of *Niobella* and the great resemblance between the cephala of *quadraticaudata* and the type species of *Niobe.* The use of additional characters may make different groupings possible. One such character is the ala, conspicuously developed in *N. frontalis* and *N. quadraticaudata,* but not particularly evident in the type and other species referred to *Niobella.* In this work I am following the practice of Lake and Bohlin rather than that of Tjernvik and Jaanusson.

NIOBE QUADRATICAUDATA (Billings, 1865)

Plates 24-26; Plate 27, figures 1-9; Text-figure 5

Billings, 1865, pp. 272-273, fig. 258.

Raymond, 1925, pp. 76-78, pl. 3, fig. 20; pl. 6, fig. 13.

Lectotype (here selected). GSC 654, incomplete and exfoliated pygidium, from the middle Table Head Formation at the type section.

Other material. All parts of the exoskeleton are fairly abundant in the middle Table Head Formation at the type section between 90 and 190 feet above the base, but rare either below or above these levels. All parts of the exoskeleton have been found in the exposures south of Table Cove and in the isolated limestone, pygidia at Black Cove, and a cranidium from the boulders at Daniel's Harbour.

Description. Cephalon wider than long, moderately convex; at the posterior margin width of cheek less than that of glabella. Latter narrowest at the midlength between the eye lobes, frontal lobe expanding to a width about equal to the width across the basal part of the glabella including the alae. Occipital furrow shallow, straight. External surface (Pl. 25, figs. 7, 10; Pl. 26, fig. 4) not impressed by glabellar furrows, but muscle areas visible on internal moulds (Pl. 25, figs. 1, 6) are shown on Text-figure 5a. The lateral part of the glabella between area 1p and 3p is slightly inflated. The ala is elongate-oval in outline, defined by the alar and axial furrows which are of similar depth, and extends from beside the occipital ring to a point opposite the most posterior part of the eye lobe. Glabellar tubercle (Pl. 25, fig. 7), low, situated in line with posterior part of palpebral lobe. Latter large, horizontal, semicircular in outline, without rim. Convex eye surface with minute facets (Pl. 26, fig. 3), separated from outer part of cheek by prominent external rim (Pl. 24, fig. 4), which is noticeably broader on the outer, anterior side of the eye lobe. Cheek outside eye lobe slopes gently outward and downward to the faintly concave, gently outward-sloping border. Latter confluent with preglabellar area, which is gently convex and forward-sloping, separated from glabella by shallow preglabellar furrow. Anterior branch of suture runs at first outward and forward, curves around over border so that branches meet in midline near outer edge of border in an oblique point. Posterior branch of suture curves outward and backward through approximately 90 degress, so that the posterior part of the fixed cheek is quarter circle in outline, subdivided by the shallow posterior border furrow. Just before the posterior branch of the suture reaches the posterior margin, it curves outward and runs over the margin. Since the genal angle is rounded the posterior part of the free cheek is tongue-shaped. Doublure is broad, the position of the inner edge revealed on the dorsal exoskeleton by a paradoublural furrow (Pl. 24, figs. 3, 4) —this edge curves forward and runs beneath the anterolateral margin of the eye lobe before it curves forward in the hypostomal notch.

Deep vincular furrow in posterolateral part of doublure (Pl. 26, fig. 9), at the posterior end of which is the small panderian opening. Hypostome subquadrangular in outline, widest across the posterolateral borders which are deeply notched. Sutural margin with oblique median point, no anterior border. Long middle body divided by deep, triangular middle furrows into a large anterior and a much smaller posterior lobe. The posterior lobe is subdivided by a median depression into a pair of inflated oval areas. Lateral border commences as a sharp fold at about half the length of the anterior lobe of the middle body, widens progressively backward, and merges with the lobate, flattened posterior border. Posterior border furrow deep behind median notch. Anterior wing triangular in form, widest posteriorly and directed vertically upward.

The one entire specimen known (Pl. 24, figs. 1, 2, 6) shows the thorax to consist of eight segments. The inner part of the pleura is horizontal and crossed by a shallow, diagonally directed pleural furrow, the outer part curved down beyond the fulcrum and broadly facetted. The pleural furrow ends against the inner edge of the facet. The mould of the external surface of the doublure (Pl. 24, fig. 6) shows the narrow band that runs beneath the posterior edge of the inner part of the pleura, and the longitudinally-directed margin of the doublure of the outer part. A flexure runs diagonally outward and forward across this part of the doublure, and the panderian opening is situated on the anterior edge of the flexure at about half its length. The pleural doublure, with its flexure and panderian opening, is extremely like that of *N. frontalis* described by Siegfried (1936, p. 14, pl. 4, fig. 3). Pygidium subquadrangular in outline, moderately convex, the broad axis tapering back and narrowing to the ill-defined tip. On the external surface of the axis only the articulating furrow is visible, but on internal moulds (Pl. 24, fig. 5) muscle areas in six or seven ring furrows are evident. The pleural regions slope gently down to the broad border, which is outward-sloping and broadest laterally. Only the first pleural furrow is visible, shallow and curving outward and backward. Doublure (Pl. 26, fig. 5) is broad, the inner margin following around the tip of the axis and the axial furrow to about half the length of the axis, then running diagonally outward and forward to the inner edge of the facet. The doublure lies close below the dorsal exoskeleton.

External surface is crossed by raised terrace lines, the arrangement of which is shown by the photographs. Notable is the difference in direction between the concentric lines on the borders of the cephalon and the longitudinal lines of the glabella (compare Pl. 26, fig. 4 with Bohlin, 1955, fig. 9). On the hypostome the terrace lines run transversely, and on the anterior slope of the posterior lobe is the smooth area which Lindström (1901, p. 63, pl. 5, figs. 19-26) interpreted as the macula. Between the terrace lines on the exoskeleton are minute pits (Pl. 24, fig. 7; Pl. 26, fig. 4), similar to those noted by Bohlin.

In the size series of cranidia (Pl. 25), little change appears to take place. In the smallest, the glabella is relatively more convex, clearly outlined, and has prominent alae like those in the largest specimens. The transitory pygidia (Pl. 27, figs. 4-9) show an extremely shallow notch in the posterior margin, and a faint post-axial ridge. Three or four segments are outlined in the anterior region, the part that is to become the true pygidium being apparently smooth.

NIOBE MORRISI (Billings, 1865)

Plate 27, figures 10-13; Plate 28; Plate 29, figures 1-3;
Text-figure 6

Billings, 1865, p. 272, fig. 257.
Raymond, 1925, pp. 78-79, pl. 6, fig. 10.

Lectotype (here selected). GSC 656, external mould of almost complete pygidium, from middle Table Head Formation at type section. Paralectotypes: GSC 656c, external mould of large pygidium (GSC 656a probably pygidium of *S. huttoni,* 656d is *N. quadraticaudata* hypostome, 656f, g are pygidia of *Peraspis lineolata*); GSC 655, a, b, three small pygidia, probably this species.

Other material. Occurs at the same stratigraphical levels and localities as *N. quadraticaudata,* but much less abundantly. At the type section it is known from 90 to 265 feet above the base of the middle Table Head, and is present in the isolated limestone at Table Cove, in Black Cove, and in the boulders at Daniel's Harbour.

Description. Billings knew only the pygidium of this species, and while Raymond figured only another pygidium, his description and the YPM collection show that he recognized all the parts of the exoskeleton here illustrated. *N. morrisi* is extremely like *N. quadraticaudata,* and the differences between the species are shown in the Plates and summarized in Text-figures 5, 6. *N. morrisi* is distinguished by the following characters:

1. The wider cheek and different course of the facial sutures. The posterior part of the fixed cheek is two-thirds the width (tr.) of the glabella, not less than half. Posterior branch of suture thus runs much farther outward before turning back, and anterior branch is more divergent in front of eye lobe—at the outermost point it is in line (exs.) with the outer extremity of the eye lobe, not the midpoint of the palpebral lobe.
2. The free cheek is thus not only of a different shape, but it is distinguished by the much stronger anterolateral projection from the external marginal rim of the eye lobe (compare Pl. 28 figs. 5, 8, with Pl. 24, figs. 1, 3, 4). The course of the paradoublural furrow is different in that it runs just outside of the eye lobe. A vincular furrow is present (Pl. 28, fig. 7), and the panderian opening is in the fold at the posterior end of this furrow.
3. The hypostome is relatively shorter and wider, the anterior sutural margin more gently curved, and the terrace lines finer and more numerous.
4. The pygidium is relatively wider, less quadrangular in outline, more gently convex, with four or five shallow ring furrows and pleural furrows. Course of inner margin of doublure is subparallel to margin of pleural region, and doublure does not extend as far inward beneath posterolateral part of pleural region. Axis is relatively narrower, and more gently tapering, but the tip in both species is ill defined.

Discussion. Specimens of small-sized parts of the exoskeleton of *Niobe* are not abundant and those that have been found do not display two types that might be assigned to these two species, and all have been placed in *N. quadraticaudata.* The great similarity between the cephala of these two species seems to require that they be placed in the same genus. The differences between the pygidia are quite considerable, yet their similar stratigraphical and geographical distribution suggests the possibility that the two ''species'' may be sexual dimorphs of one species.

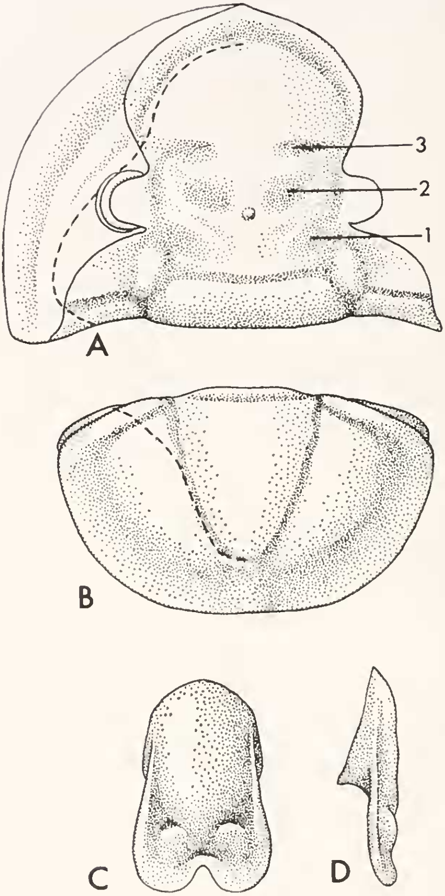

Fig. 5. *Niobe quadraticaudata* (Billings), middle Table Head Formation. A, cephalon lacking right free cheek, dorsal view; B, pygidium, dorsal view; C, D, hypostome, exterior, right lateral views; × 1. 1-3, muscle areas. Dotted line shows position of inner edge of doublure. Compare Plate 24, figures 1-5; Plate 25, figure 1; Plate 26, figures 1, 2, 5-8; Plate 27, figures 1-3.

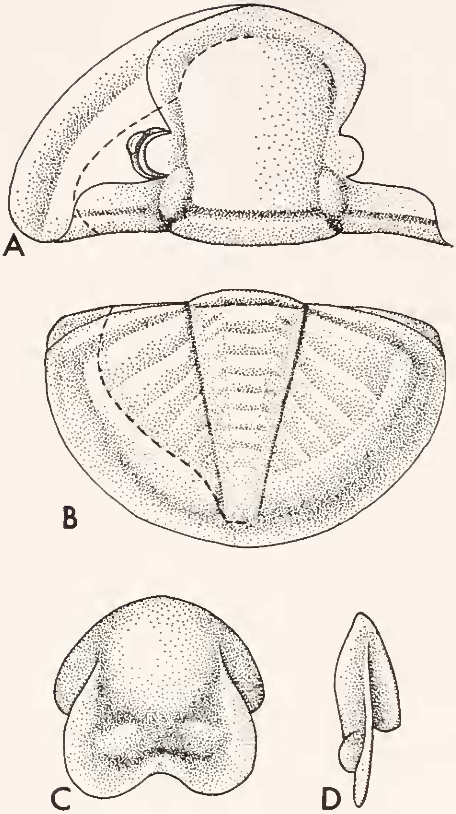

Fig. 6. *Niobe morrisi* (Billings), middle Table Head Formation. A, cephalon lacking right free cheek, dorsal view; B, pygidium, dorsal view; C, D, hypostome, exterior, left lateral views; X 1. Dotted line shows position of inner edge of doublure. Compare Plate 27, figures 10-13; Plate 28; Plate 29, figures 1-3.

Asaphid protaspis

Plate 29, figures 4-11

Material. Two incomplete examples, one from the isolated limestone, the other from Table Cove.

Description. The shield is strongly convex, the anteromedian area flattened but the pleural regions steeply sloping, the posterior portion narrower (tr.) and curled under so that the longitudinal convexity is greater than the transverse convexity. In the anterior half subparallel axial furrows outline the gently convex axis which is slightly narrower (tr.) than the adjacent pleural regions. In both specimens the anterior edge of the shield is broken so that the most anterior portion is not preserved. Only in one (Pl. 29, fig. 5), on the right side, is the axial furrow seen to expand into the anterior pit. Posteriorly the axis widens slightly before it is crossed by a shallower furrow which runs in a curve convex backward. In one specimen (Pl. 29, figs. 4-6) the narrower, posterior part of the shield behind the transverse axial furrow is not subdivided. In the second specimen the exoskeleton is adhering to part of this posterior area and there is evidence of subdivision. On the internal mould exposed on the left side (Pl. 29, figs. 7, 10, 11), an extremely faint axial furrow runs back and apparently dies out, and the axial region is faintly convex. The pleural regions are clearly divided by subparallel furrows which run almost straight out to the margin. On the external surface (Pl. 29, fig. 9) these divisions are outlined by smooth bands in the finely granulate external surface. About five segmental divisions may be seen, which become successively shorter (exs.) posteriorly. What appears to be the broken base of a spine, situated on the steep outer part of the pleural region and in a transverse line which lies in front of the trans-axial furrow, is visible on both specimens (Pl. 29, figs. 6, 9-11).

Discussion. In general form, width and length of that part of the axis outlined by furrows, and presence of the anterior pit, this protaspis resembles those of asaphids described by Evitt (1961). The resemblance is greatest to the late protaspis of Evitt (1961, pp. 988-991, text-fig. 3, pl. 117, figs. 9-12, 17, 18), which has the axis outlined on the anterior part of the shield, and shows segmentation in the posterior region. The maximum width (tr.) of the specimens described by Evitt is approximately 1 mm, whereas that of the present examples is 1.5

mm. Because of the size they may be presumed to represent a later developmental stage than Evitt's examples, and other features suggest this. One such is the furrow across the axis at the midlength, which may be either at the posterior margin of the glabella, or, because of its curvature, the occipital furrow. The preservation of the Table Head specimens is such that neither the anterior nor the posterior pair of spines, if present, can be seen. But the pair at the midlength on the pleural region is unlike any in Evitt's specimens, and is in the position of the fixigenal spines of the remopleuridid protaspis (Whittington, 1959, pp. 397-398). Evitt (1961, pp. 994-995) compared and contrasted the remopleuridid and asaphid protaspis, and, on the hypothesis he favours, this pair of spines would be the posterior pair of earlier developmental stages that have migrated forward and outward. Whether or not this hypothesis is accepted, these Table Head protaspides are asaphid rather than remopleuridid in form, and display a fixigenal spine in the midlateral region.

There is no sign in the protaspis of the lobe at the posterolateral margin of the glabella, so characteristic of meraspid asaphid cranidia (Pl. 22, fig. 11; Pl. 25, fig. 12; Evitt, 1961, pl. 117, figs. 20, 23; Whittington, 1941, pl. 75, fig. 27). This lobe is lost during development in some genera (*Stegnopsis* n. gen., *Isotelus*) but is retained in *Niobe* (Pl. 25, figs. 1, 6, 7, 8, 10, 12). In this latter genus it has been termed an alar lobe, implying that it lies outside the axial furrow. More knowledge of asaphid developmental stages is needed to establish the nature of this lobe, and to show whether or not it is homologous in all genera.

Asaphid ? hypostome

Plate 67, figures 5, 7, 8

Material. GSC 18370, an incomplete specimen from Table Cove.

Description. Middle body gently convex, oval depression situated close to lateral margin and at three-fifths the length, the posterior lobe marked off as a crescentic, gently convex region, the tip of which abuts against the depression. No anterior furrow or anterior border, anterior margin straight, transverse, the large, triangular wing inclined to slope upward and backward. The anterolateral corner of the hypostome is acutely angulate, the margins of the wing are straight and the tip rounded. Lateral and posterior borders broken off, but the appearance on the right side (left in Pl. 67, figs. 5, 7) suggests that the lateral border projected in a shoulder. The form of the posterior border is uncertain. External surface bearing faint lines running transversely in curves which are gently convex back; the lines run continuously from the proximal part of the wing across the middle body; on the distal part of the wing the lines run across and are curved progressively more strongly toward the tip.

Discussion. The general form of this hypostome and, particularly, the large, upwardly-projecting wing, suggest it belongs to either an asaphid or an illaenid. Hypostomes of the latter family (Pl. 45, figs. 14, 15; Pl. 52, figs. 6-13; Jaanusson, 1954, pl. 2, figs. 1, 6; pl. 3, figs. 1, 5, 7), however, have the lateral borders narrow and not projecting as a shoulder. Thus it seems more likely that this example belongs to an asaphid species, but it is unlike those (Pl. 23, figs. 3-5, 8; Pl. 26, figs. 1, 2, 6-8; Pl. 29, figs. 1-3) here assigned to the asaphid species in the middle Table Head Formation.

Family NILEIDAE Angelin, 1854

Genus NILEUS Dalman, 1827

NILEUS AFFINIS Billings, 1865

Plate 30, figures 1, 3, 5, 7; Plate 31, figures 1-6, 8, 10

Billings, 1865, p. 275, figs. 261a, b.

Whittington, 1963, pp. 53-55, pl. 9, figs. 7, 9-12; pl. 10, figs. 1-7, 10, 13.

Nileus scrutator (part), Whittington and Kindle, 1963, fig. 3.

Material. This species is moderately abundant in unit 8 of the lower Table Head Formation at the type section, and at exposures of a similar age near Pointe Riche. It is also the most abundant species of *Nileus* in the middle Table Head, found throughout this part of the formation. It is present in the isolated limestone, at Table Cove, and probably in boulders at Daniel's Harbour. The two exoskeletons mentioned by Billings (1865, p. 275) and referred to *N. scrutator*, belong in *N. affinis* (GSC 720, 720a, from the type section).

Discussion. The present material appears indistinguishable from the type specimens and those from the boulder at Lower Head. The abundant material has revealed various additional features of the exoskeleton, particularly the doublure and hypostome.

The exoskeleton is thick, and internal moulds of the cephalon show the glabellar tubercle prominently, a deep groove in the cranidium beside the anterior edge of the eye lobe (Pl. 30, fig. 3), a broader and shallower furrow on the free cheek outside the eye surface. The cephalic doublure is well shown in a specimen which has the hypostome preserved though slightly displaced (Pl. 31, figs. 1, 5). Anteriorly the doublure is broadest, with a wide furrow running beside the hypostomal suture, and a notch in the inner margin against which the hypostome fits along the suture. Anterolaterally, the inner part of the doublure is curled upward and outward, most strongly so laterally, where the ventrally-facing part is impressed by a vincular furrow. Immediately behind this furrow the doublure is flexed abruptly, and posterolaterally it is flat and lies close beneath the dorsal exoskeleton. Hypostome (Pl. 31, figs. 2-4, 6) twice as wide as long, anterior sutural edge straight, margins of lateral borders curved, posterior margin indented by shallow median notch. A narrow raised rim runs around the edge of the lateral and posterolateral borders, dying out as it approaches the median notch. Inside this rim the surface of the hypostome is almost flat, except for the deep, suboval depression of the macula, which is situated anterolaterally, a short distance inside the rim and in line with the anterior edge of the shoulder. The anterior wing is extremely long, directed vertically. The anterior edge is only slightly curved, the proximal part of it fitting against the doublure. In lateral aspect (Pl. 31, fig. 3) the wing is triangular in outline, but ''L''-shaped in transverse section, for the posterior edge is bent so that there is an inwardly extending part of the wing (Pl. 31, fig. 2). When the hypostome was in position, it appears that the tip of the wing would lie close to the dorsal exoskeleton of the anterior part of the glabella, approximately in line with the anterior end of the eye lobe, and a short distance in from this point.

Five complete specimens show that there are seven thoracic segments, and one (Pl. 31, fig. 8) shows the segments in ventral aspect (cf. Schmidt, 1904, p. 66, fig. 6). On the inner surface of the exoskeleton the lateral part of the ring is deeply excavated, the articulating furrow standing up as a thick ridge. On the external surface of the exoskeleton the ring is quite smooth, so that these features are produced by thickenings of the exoskeleton, particularly along the articulating furrow. At the posterior margin of the ring, at the axial furrow, there is a prominent articulating boss, which is seen to fit into a deep socket in the anterior margin of the succeeding segment. Again, these structures are in the thick exoskeleton, and only slightly reflected in the dorsal surface. The doublure of the pleurae extends in close to the axial furrow, the inner margin gently concave inward. This doublure is crossed by a diagonally directed fold, which acts as a stopping device for the leading edge of the succeeding segment during enrollment. The pygidial doublure (Pl. 31, fig. 10) is wide, extending in around the posterior half of the axis and beneath all but the inner, anterior part of the pleural region. It lies close against the dorsal exoskeleton. The distribution of the prominent terrace lines on the hypostome, and on doublure of the thorax and pygidium, is shown by the photographs.

The hypostome differs from that of *Nileus armadillo* (Lindström, 1901, pl. 5, fig. 13) in that the middle body is not defined by shallow furrows, and the maculae are situated much farther forward and are in the form of deep, flat-based pits. Whether or not the anterior hypostomal wing is similarly shaped in the two species is uncertain. The general appearance of the hypostome of *N. affinis,* and particularly the extreme shortness (sag. and exs.) of the anterior lobe of the middle body, suggests a comparison with the hypostome of *Remopleurides* (Whittington, 1959, pp. 393-396, text-fig. 3). It may well be that the anterior wing in these two genera is homologous, and if so, the possibility of a relationship between remopleuridids and nileids is suggested. In common between the two families are the wideness of the doublure, particularly of the thoracic pleurae and pygidium, and the articulating processes and sockets situated in the axial furrow.

NILEUS SCRUTATOR Billings, 1865

Plate 30, figures 2, 4, 6, 8-14; Plate 31, figures 7, 9;
Plate 32, figures 1, 3, 5, 7, 9

Billings, 1865, pp. 274-5, fig. 260.
Raymond, 1925, pp. 84-85, not pl. 3, fig. 17.

Lectotype (here selected). GSC 667a, incomplete cephalon with exoskeleton partly exfoliated. Paralectotypes include 667, 677b, c, three pygidia, and 667d, a cranidium. All are labelled as from Portland Creek; 667d, however, bears the label "4 miles NE of Portland Creek" and is from Daniel's Harbour.

Other material. In the present investigation this species has been found to be rare, a few specimens coming from 90 feet above the base of the middle Table Head Formation, one cranidium from 215 feet above the base, and one pygidium from the exposures on the foreshore south of Table Cove.

Description. The complete enrolled specimen (Pl. 30, figs. 2, 6, 9, 12; Pl. 31, figs. 7, 9) shows the characters of the dorsal exoskeleton, and how it may be distinguished from *N. affinis.* The eye lobe is relatively shorter, the free cheek relatively wider and more prolonged posterolaterally. But the most obvious distinguishing feature of the cephalon is the sharp flexure at the anterior and anterolateral margins between the dorsal exoskeleton and the horizontal doublure. Running along the sharply flexed margin is a narrow rim. In *N. affinis* there is no such rim and the margin is broadly rounded (compare Pl. 30, figs. 7, 9). On the internal mould the glabellar tubercle is much less conspicuous, and the shallow groove along the posterior margin of the glabella is less pronounced (compare Pl. 32, fig. 1, with Whittington, 1963, pl. 10, fig. 1). There are seven thoracic segments in both species, and in dorsal aspect the pygidia are similar, except that in *N. scrutator* there is a flattened border to the pygidium, which is widest laterally; though faintly defined this is more distinct than that of *N. affinis.* The eye surface is covered with closely spaced facets which are arranged in diagonal lines (Pl. 31, fig. 7). The small cranidium (Pl. 30, figs. 10, 11, 13) differs from larger cranidia in being more convex both transversely and longitudinally.

Raymond identified this species both from boulders in the conglomerate at Mystic, Québec, and from beds of Porterfield age in Virginia and Tennessee. The material he studied suggests that a species of *Nileus,* of *affinis-scrutator* type, is present in the boulders in Québec, and that a nileid of this general type is present in the southern Appalachians.

NILEUS MACROPS Billings, 1865

Plate 32, figures 2, 4, 6, 10, 12-14 ; Plate 33, figures 1-6

Billings, 1865, p. 273, fig. 259.
Raymond, 1925, pp. 83-84.

Lectotype (here selected). GSC 649a, incomplete and partly exfoliated exoskeleton, from middle Table Head Formation at type section. Paralectotypes: GSC 649, a less complete and almost entirely exfoliated exoskeleton, 649b, cephalon with one segment, 649c, cranidium, same locality and horizon.

Other material. This species has been found to occur less commonly than *N. affinis,* but more commonly than *N. scrutator,* in the middle Table Head Formation at the type section from 90 feet above the base to the top, in the isolated limestone, the exposures at Table Cove, and in the boulders at Daniel's Harbour.

Description. The cephalon is distinguished from that of *N. affinis* and *N. scrutator* by the much longer (exs.) eye lobe, the narrower (tr.) free cheek, the steep slope of the cephalon in front of the eye lobes, the parallel course of the anterior branches of the facial suture immediately in front of the eye lobes, and the more strongly convex transverse profile. The cranidium is not, as Raymond believed, ''much longer and narrower than in *N. scrutator*'' (compare Pl. 32, fig. 2 with fig. 1), and the glabellar tubercle appears to be in much the same position in the two species, and moderately prominent on the internal mould. The entire specimens show that there are seven thoracic segments. The pygidium has the outer parts of the pleural regions slightly flattened, though there is no distinct border, and displays a broad, shallow first pleural furrow running immediately inside the inner part of the facet. The doublure extends in to the tip of the axis and about half way across the pleural regions, not quite as far in as in *N. affinis.*

NILEUS? LACUNOSA n. sp.

Plate 36, figures 1-10; ?Plate 32, figures 8, 11

Holotype. GSC 18549, incomplete cephalon from middle Table Head Formation at Table Cove.

Other material. One cranidium from boulder at Daniel's Harbour, one incomplete cranidium (and a pygidium that may belong here) from middle Table Head Formation, type section, 190 feet above base.

Description. Cephalon subsemicircular in outline, moderately convex, facial sutures nileid, slim genal spine. Eye lobe large, bearing many small facets on eye surface, length (exs.) greater than half that of cephalon. No axial furrow separates palpebral lobe from glabella, the two being united in a smooth, convex curve. Frontal lobe of glabella and preglabellar area, as well as outer part of cheek, slope evenly and gently to sharply flexed margin of cephalon; there is no cephalic border as such but a flattened anterolateral region. As the cranidium (Pl. 36, figs. 5, 8, 9) shows, the glabella is most sharply convex close to the posterior margin. The small cephalon (Pl. 36, figs. 3, 6, 7) is more convex, has much broader-based genal spines and the flattened anterolateral border region is pronounced.

*Discussion.*The cephalon is like that of *P. lineolata,* but the lack of the border and axial furrows distinguishes it at once. Also distinctive are the tiny pits of the external surface of the glabella and palpebral lobes (Pl. 36, fig. 10), which become faint or die out on the cheek outside the eye lobe. The cephalon, and particularly the cranidium, is like that of *Nileus*, but the gentle slope outside and in front of the eye lobes, and the genal spines, distinguish it. An exoskeleton in which the cephalon is damaged, from a boulder north of the mouth of Portland Creek, suggests that the original of Plate 32, figures 8, 11, may represent the pygidium of this species. If so, this pygidium, distinguished by its subtriangular shape and flattened borders, is far more like that of *Nileus* than *Peraspis,* and this species is put with question in the former genus.

Genus PERASPIS n. gen.

Type species. Niobe lineolata Raymond, 1925.

Diagnosis. Broad anterior cephalic doublure not crossed by median suture, anterior branches of suture meeting on dorsal surface close to anterior margin in a smooth curve. Glabella subparallel-sided, slightly expanded anteriorly, without furrows, but glabellar tubercle close to posterior margin. Large eye lobe situated at midlength of cephalon adjacent to axial furrow, cheeks with flattened border, anterolaterally, which is continuous with flattened preglabellar area. Posterior part of fixed cheek extremely small, posterior border furrow on free cheek, short genal spine. Hypostome (that probably belongs here) transversely ovate in outline, no median notch, median furrow situated at midlength. Seven thoracic segments; pleural furrow runs close to anterior margin then curves distally beside facet and deepens. Pygidium with narrow tapering axis, pleural regions with narrow flattened border, four or five axial rings and pleural furrows present. Doublure wider than border, inner margin concentric with pygidial margin, except at notch behind axis. External surface covered with closely-spaced, extremely fine lines, which run in curves convex forward on the axis, and diagonally on the pleural regions.

Discussion. Raymond placed this species in the Asaphidae, but the discovery that the anterior cephalic doublure is broad (sag. and exs.) and lacks the median notch and median suture, suggests that this species is a nileid. The shape of the glabella and lack of furrows, large eye lobes placed close to glabella, seven thoracic segments, type of pleural furrow, and fine lines of the external surface are characters typical of nileids rather than asaphids. The cephalon is like that of *Kodymaspis* Prantl and Přibyl, 1949, in possessing genal spines, but the furrowed pygidium is asaphid-like and not like that of other known nileids.

PERASPIS LINEOLATA (Raymond, 1925)

Plates 34, 35; Plate 36, figures 11, 12

Raymond, 1925, pp. 79-80, pl. 3, figs. 15, 16.

Holotype. YPM 13042, exoskeleton lacking free cheeks, middle Table Head Formation, Dominion Iron and Steel Company quarry, Aguathuna, Port au Port peninsula.

Other material. Middle Table Head Formation, from 130 to 190 feet above the base in the type section, the isolated limestone, exposures on foreshore south of Table Cove, at Black Cove, and in boulders at Daniel's Harbour. GSC 656f, g, two small pygidia from the type section, placed by Billings in *Niobe morrisi.*

Description. Cephalon subsemicircular in outline, gently convex, border widest anteriorly and anterolaterally, narrowing toward genal angle which is prolonged by short spine. Glabella subquadrangular in outline, about twice as long (sag.) as wide, bounded by shallow, sinuous, axial furrow and shallow preglabellar furrow. No occipital or lateral furrows, faint glabellar tubercle situated close to posterior margin; glabella slightly expanded across frontal lobe. Large eye lobe of length (exs.) almost half that of cephalon, situated beside axial furrow, posterior margin adjacent to posterior border furrow. Palpebral lobe flat, without rim; eye surface (Pl. 35, fig. 7) bearing many small convex facets and bounded by narrow, convex external rim. Anterior branches of suture diverge forward from eye lobes, curve around and meet in a smooth curve, the anterior part of their course running close to the margin of the cephalon (Pl. 35, figs. 3, 5, 7). Posterior branch of suture runs directly outward and slightly backward, so that the posterior part of the fixed cheek is a wide (tr.), short triangle. Cheek inside border gently convex, boundary of this convex region curves around to abut against anterior margin of eye lobe. Broad, shallow depression, the border furrow, separates this convex region from the outward sloping border — this depressed region widest (exs.) in front of eye lobe and beside frontal lobe of glabella. Preglabellar area horizontally extended, gently convex. Posterior border furrow runs directly outward and is situated on free cheek; at genal angle it becomes shallower and curves forward to join lateral border furrow. Genal spine is broad at base, tapering rapidly to sharp tip. Doublure of cephalon extends inward so that inner margin is beneath margin of convex part of cheek (Pl. 35, figs. 3-5), this line curving around and then running transversely immediately in front of eye lobes, so that anterior part of doublure is broad (sag. and exs.). Adjacent to midline inner edge of doublure is flexed. A small projection on the inner surface of doublure at genal angle (Pl. 35, figs. 1, 2) acts as a stop during enrollment, and does not appear to show a panderian opening. Hypostome poorly preserved in place in one specimen (Pl. 35, fig. 1). Isolated specimens from Daniel's Harbour (Pl. 35, figs. 6, 8) and the isolated limestone may represent the same species. Outline oval, maximum width slightly greater than length, gently convex, the wing curving upward. The median furrow is a slight, broad depression running inward at about the midlength. A low, narrow posterior border projects in a blunt, median point.

Thorax of seven segments, axis of constant width; posterior segment the widest (tr.), where the axis is about one-quarter the total width, contrasting with the first segment, in which the axis is about one-third the width. Pleurae facetted so that tip is a sharp point, pleural furrow shallow and close to anterior margin on inner part, at fulcrum curving and deepening as it runs along the inner margin of the facet, shallowing and dying out without reaching the tip. Pygidium with narrow axis that tapers gradually to faintly defined tip at the posterior margin. Articulating furrow narrow. First six ring furrows are best defined distally, faint or absent medially. Pleural regions gently convex, sloping down distally to narrow, more gently sloping but ill-defined border. Five pleural furrows curve slightly distally and die out without reaching the border. The doublure (Pl. 34, fig. 10) is wider than the border, situated close against the dorsal exoskeleton, extending inward about one-third the width of the pleural regions, the inner margin parallel to the margin of the pygidium, notched where it extends beneath the tip of the axis.

External surface (Pl. 34, fig. 9; Pl. 35, fig. 7; Pl. 36, figs. 11, 12) covered by closely-spaced, extremely fine lines. These lines run in curves that are gently convex forward on the axis, and run diagonally inward and backward on the pleural regions, changing distally to run subparallel to the margins. On the doublure (Pl. 34, fig. 10; Pl. 35, figs. 1, 2, 4) the terrace lines are much coarser, and run subparallel to the margin. On the hypostome (Pl. 35, figs. 6, 8) the lines are coarse and run transversely.

Discussion. The small cranidium (Pl. 34, figs. 8, 11, 12) is relatively tumid, the glabella being slightly more convex, both transversely and longitudinally, than in larger examples. A transitory pygidium (Pl. 34, figs. 6, 7) has the pleural regions relatively more inflated so that the narrow border is much more distinct. A second example of a transitory pygidium (Pl. 67, figs. 10, 13) is similar in size, convexity, and in the presence of the border, to the original of Plate 34, figures 6, 7. The anterior segment is faintly marked off by an interpleural furrow, the pleural furrow is broad and shallow, running for a short distance immediately behind the inner part of the facet. This specimen lacks axial furrows outlining the axis on the part that is to become the true pygidium, and does not show shallow pleural furrows in this region. It is tentatively referred to this species.

Raymond referred this species without discussion to *Niobe,* but the additional material does not support this view. Whittard's (1961, pp. 221-228, pl. 31, figs. 6-11, pls. 32, 33) recent description of species of the nileid *Barrandia* show the wide anterior cephalic doublure and the extremely fine lines on the external surface of the dorsal exoskeleton, much as in *N. lineolata.* The hypostomes in the two genera are similar in shape, but the middle furrow in *Barrandia* is deep and continuous across the middle body. In other respects the cephalon and pygidium in the two genera differ considerably, but the family likenesses are evident.

NILEID gen. ind.

Plate 33, figures 7-13

Material. A single cranidium retaining full convexity from bed 4 of the middle Table Head Formation, Black Cove. MCZ 3652, a fragment of a similar cranidium and the free cheeks joined by the doublure, both specimens flattened, labelled "east side, Port au Port," and probably from the same locality and horizon, collected by A. Hyatt. Two pygidia from Black Cove may belong here.

Description. Gently convex glabella outlined by shallow, parallel, axial furrows that run forward to the inner, anterior corner of the palpebral lobe. In front of this point glabella expands and slopes steeply down to sutural margin of cranidium. The eye lobe is of length (exs.) about one-third that of the cephalon, and situated at about the midlength. Palpebral lobe is horizontal, cheek slopes gently outward. The anterior branches of the suture are widely divergent immediately in front of the palpebral lobe, then run in a smooth curve around the margins of the frontal glabellar lobe. Small glabellar tubercle situated in line with the posterior part of the palpebral lobe. The free cheek is wide (tr.), subtriangular in shape, genal angle rounded, the anterior cephalic doublure of width (sag.) about one-third the length of the cephalon, a shallow median notch in the inner margin, adjacent to which is a shallow groove in the external surface. A few terrace lines curve across the genal angle.

The pygidium included here is the only unassigned pygidium known from bed 4 at Black Cove, and may belong with the cephalon. Axis tapers to rounded tip, first ring furrow and first pleural furrow shallow but distinct. Narrow, flattened border, doublure of about twice the width of the border.

Discussion. The cephalon lacks median or connective sutures, and is clearly a nileid. However, the axial furrow, the difference in slope between glabella and palpebral lobe, and the size and position of the eye lobe, distinguish it from species of *Nileus* described here. The pygidium is quite unlike that of *Nileus,* being relatively longer, and in having a longer, narrower axis and the distinct border. From *Peraspis* n. gen. the cephalon is distinguished by the more forward position of the glabellar tubercle and lack of genal spines, the pygidium being differently furrowed, and the external surface being smooth.

Family TELEPHINIDAE Marek, 1952

Genus TELEPHINA Marek, 1952

TELEPHINA AMERICANA (Billings, 1865)

Plate 37; Plate 38, figures 7-9, 11

Billings, 1865, pp. 291-292, fig. 281.
Hadding, 1913, pp. 41-42, pl. 1, fig. 11, text-fig. 1.

Raymond, 1925, pp. 65-66.
Ulrich, 1930, pp. 21-22, pl. 2, figs. 22-27.

Lectotype (selected by Ulrich). GSC 700b, incomplete and exfoliated cranidium, from middle Table Head Formation, type section. Paralectotypes: GSC 700, 700a, two cranidia from the same locality as the lectotype; GSC 699, a-e, six cranidia from Daniel's Harbour.

Other material. Relatively abundant in the type section of the middle Table Head Formation, from 90 feet above the base to the top; also abundant in the isolated limestone, at Table Cove, and the boulders at Daniel's Harbour.

Description. Glabella of maximum width across occipital furrow, tapering forward and rounded anteriorly, moderately convex longitudinally and transversely. The occipital furrow is deep and straight, with a slight extra deepening distally, outside which it curves forward and dies out without reaching the axial furrow. Low, longitudinally-elongate median occipital tubercle on external surface (Pl. 37, fig. 5), barely visible on internal mould (Pl. 37, figs. 1, 3). On the internal mould (Pl. 37, figs. 1, 3) a faint, shallow depression at about half the length may indicate the presence of the first lateral glabellar furrow. Axial furrows deep and forming a continuous curve with preglabellar furrow, anterior pit at the junction of these furrows. Fixed cheek consisting of crescentic area adjacent to axial furrow, flexed down where it joins the palpebral rim; the latter a gently convex, outward-sloping band which is slightly wider anteriorly than posteriorly. Anteriorly (Pl. 37, fig. 18) the palpebral rim abuts against the axial furrow at the anterior pit; in front of this is the anterior border, which is narrow, convex, runs straight across in front of the middle part of the glabella, and is distally turned downward to form a spine, the outer edge of which is bounded by the anterior branch of the suture. Posterior border also spine-like in form, curving outward and downward, and bounded on the anterior side by the posterior branch of the suture. Free cheek (Pl. 37, figs. 14-17) includes the large, convex eye surface, covered with many convex facets. This surface is bounded on the outer side by a deep furrow, outside which is the narrow border. This border expands to a maximum width posterolaterally, has the upper and lower edges sharply flexed, and there is a small, short librigenal spine at the widest part. External surface covered by raised lines, which on the glabella (Pl. 37, fig. 18) are arranged in a multiple web-like pattern because individual lines radiate from low tubercles. Immediately in front of the outer part of the occipital furrow is a transversely elongate, smooth area, an area of muscle attachment which lies in front of the deep outer part of the occipital furrow. Beside this area the axial furrow is deepened. A second area (lateral glabellar furrow 1p) is represented by a large oval, smooth area, which is diagonally directed and situated at about half the length of the glabella, and a short distance in from the axial furrow. A much smaller area just in front of it may represent furrow 2p. The inner, posterior part of the palpebral lobe is smooth, and this area may also be a muscle area.

The small cranidium (Pl. 37, figs. 8, 12, 13) is like larger specimens except that the palpebral lobe is wider and consequently has an angulate outline.

Pygidium triangular in outline, axis of width (tr.) at the anterior margin half that of the pygidium, consisting of two rings and a small terminal piece, and rapidly tapering to the bluntly rounded tip. Behind the axis is a low, postaxial ridge. Pleural regions narrow, outward sloping, with a narrow, wirelike rim which merges with the postaxial ridge at the tip. Anterior margin of pleural region a raised ridge, the furrow behind this presumably being the first pleural furrow, and the faint ridge following being the posterior band of the first pleura. First and second axial ring displaying a prominent pair of tubercles close together at the midline. Behind these tubercles is a faint flexure, which runs out laterally, and curves around distally to reach the posterior margin. Thus the posterior half of the first axial ring is slightly lower than the anterior half, and the latter bears a few scattered tubercles. On the posterior part of the axis is a pair of oval, slightly depressed regions, situated close behind the median pair of tubercles, and bearing some scattered tubercles. Raised terrace lines run along the rim and diagonally on the axial ring.

Discussion. Specimens that are not exfoliated (Pl. 37, fig. 18) reveal the unusual arrangement of tubercles and raised lines on the external surface, which are visible only as faint tubercles on internal moulds (Pl. 37, fig. 3). A somewhat similar arrangement of lines and smooth muscle areas appears to be present in *Telephina bipunctata* (Ulrich, 1930, pl. 5, figs. 1-6). Ulrich compared the present species to his *T. mysticensis* (1930, pp. 22-23, pl. 6, figs. 1-7). The cranidia of the two species appear similar, but the eye lobe in *T. americana* is much less convex; in both species there is only a small, short, genal spine. The pygidium appears to be of normal telephinid type, but it is difficult to compare it in detail with such specimens as those illustrated by Ulrich (1930).

A single example of a hypostome (Pl. 37, figs. 10, 11) comes from the exposures on the foreshore south of Table Cove, in which beds *T. americana* is abundant. The middle body is elongate-oval, divided by a shallow but complete middle furrow, the anterior lobe the larger and the more convex. The tip of the posterior lobe is slightly inflated. The wide anterior border extends forward horizontally, and has a shallow median depression in the anterior edge. Laterally it is continuous with the large, triangular wings which are curved upward. The lateral and posterior borders are narrow, wire-like, defined by deep border furrows. The specimen appears to be exfoliated, but there is exoskeleton adhering to the borders, and it is traversed by fine terrace lines. Whether or not this hypostome belongs in *T. americana* is uncertain, but it is similar to the hypostome of *T. mysticensis* figured by Ulrich (1930, pl. 6, fig. 5). This illustration shows no wide anterior border, but apparently it is broken and there is a large anterior wing. The general aspect of the middle body and borders is similar to the present specimen.

Nikolaisen (1963) has described Middle Ordovician telephinids of Norway, and discussed the phylogeny of the group. As he remarks, *T. americana* and its close relative *T. mysticensis* (with which he associates, with some doubt, *T. gelasinosa* Ulrich from beds of early Porterfield age in Alabama) differ from Norwegian species in that the fixed cheek is relatively narrow (tr.) and well rounded. He describes only fragmentary free cheeks and pygidia, which are like those from Newfoundland and Quebec except that the cheeks bear a long genal spine. The external surface of the Norwegian species is tuberculate, and Nikolaisen describes reticulate or anastomosing raised lines, but the preservation does not reveal a pattern like that in *T. americana* (Pl. 37, fig. 18). Other features of the cranidium are shown in Nikolaisen's figures — the smooth, oval area immediately in front of the deep outer part of the occipital furrow, the smooth area on the posterior part of the fixed cheek, and the deep, elongate anterior pit (Nikolaisen, 1963, pl. 1, figs. 6, 11; pl. 2, fig. 2; pl. 3, figs. 1, 12). The Norwegian and American species of *Telephina* thus appear to be related, *T. americana* and *T. mysticensis* occurring at about the same time as the early Norwegian species and apparently representing a separate species group.

Small cranidia of *Telephina bicuspis* (Nikolaisen, 1963, pl. 1, figs. 1-4) have the fixed cheek no wider (tr.) than in large individuals, and lateral furrow 1p impressed, unlike that of the small cranidium of *T. americana* (Pl. 37, figs. 8, 12, 13).

TELEPHINA sp. ind.

Plate 38, figures 1-6, 18

Material. Three cranidia, partly exfoliated, from middle Table Head Formation at Table Cove.

Description. These three cranidia differ from those of *Telephina americana* in that the glabella is relatively wider posteriorly and tapers slightly more rapidly, and the occipital furrow is not straight but distally turns back, becomes deeper, then curves forward to become shallower but reaches the axial furrow. Thus the outer part of the occipital furrow is curved concavely forwards. The median occipital tubercle is more distinct, particularly on the internal mould. The palpebral rim is also different in that the anterior part is considerably wider, so that the anterior margin of the cranidium in dorsal aspect appears almost straight, distally curving sharply so that the anterolateral margin of the palpebral lobe is more angulate than in *T. americana.* The exterior surface bears a similar pattern of scattered tubercles from which fine lines radiate, giving a characteristic stellate appearance. The muscle area in front of the outer part of the occipital ring is represented by an oval smooth area, and lateral glabellar furrow 1p by a similar-appearing area that is diagonally directed and situated at about the midlength of the glabella. The differences appear to exist between both large and small cranidia.

Family KOMASPIDIDAE Kobayashi, 1935

Genus GONIOPHRYS Ross, 1951

GONIOPHRYS BREVICEPS? (Billings, 1865)

Plate 38, figures 10, 12-17; Plate 39, figures 1, 2, 5, 6, 10

Billings, 1865, p. 262, fig. 246.

Types. The specimen or specimens on which Billings based his description have not been traced. They came from the type section of the middle Table Head Formation. GSC 2254 is a cranidium from Portland Creek, collected by J. Richardson, but not the original of Billings' figure.

Other material. Ten cranidia from the isolated limestone and Table Cove, and one from 17 feet above the base of the type section.

Description. No cranidia of a length (sag.) greater than 2.5 mm have been found. Glabella widest across base, tapering forward and bluntly rounded, length slightly less than maximum width. Occipital furrow deep and narrow, course slightly bow-shaped, deepest distally, posterior margin of ring curved convexly backward. Glabella defined by deep and continuous axial and preglabellar furrows, in front of glabella a short (sag. and exs.), convex preglabellar field and a somewhat longer, convex anterior border. Fixed cheek is gently convex, outward sloping, anteriorly merging with the preglabellar field and bounded by the anterior border. Posterior border furrow narrow and deep, posterior border widening outward. Lateral margins of fixed cheeks almost straight, converging forward, narrow palpebral rim defined by deep palpebral furrow, having a gentle outward curvature, and running from just in front of posterior border furrow almost to anterior border furrow. The anterior border is curled under, and the anterior branch of the suture runs inward and forward on to the upper surface of this border, then turns to run inward and downward across the ventrally-facing surface of the border (Pl. 39, figs. 5, 6). The two branches do not appear to meet in the middle line, but appear to be joined by what may be the rostral suture, running in a curve that is convex forward.

External surface (except borders and in furrows) bearing scattered shallow pits. On the glabella, muscle areas are represented by smooth, unpitted patches (Pl. 38, fig. 17 ; Pl. 39, figs. 1, 10) — a large oval one extending from the axial furrow inward and backward at about the midlength of the glabella, and a smaller area situated on the anterolateral slope of the glabella and widening as it extends inward from the axial furrow. Traversing the anterior border are fine terrace lines.

The smallest cranidium (Pl. 38, figs. 10, 13, 14) is like the larger, except that the external surface is tuberculate rather than pitted. This cranidium displays the same smooth areas on the glabella.

Discussion. The forwardly tapering glabella, with well-defined occipital ring and two pairs of muscle areas, the short preglabellar field and long, prominent palpebral rim suggests that this cranidium is that of a komaspidid. It resembles most closely *Goniophrys* Ross (1951, pp. 81-82, pl. 18, figs. 9, 15, 17-20, 22, 27; Hintze, 1953, pl. 20, fig. 1), but differs from the type and only known species principally in that the palpebral rim in dorsal aspect is not so sharply flexed. There is no shallowing of the axial furrow adjacent to the glabella in front of the occipital ring, as described by Hintze (1953, pp. 156-157). The type species is not pitted on the external surface and does not display the smooth muscle areas, but the glabella is unfurrowed.

Genus CAROLINITES Kobayashi, 1940

CAROLINITES sp. ind. 1

Plate 39, figures 3, 4, 11

Material. A single cranidium (GSC 18567), partly exfoliated, from bed 4 of middle Table Head Limestone, Black Cove.

Description. In outline and convexity of the glabella, shape of fixed cheek, and presence of the convex lobe adjacent to the glabella in front of the occipital ring, this cranidium is like that of other species of this genus (Stubblefield, 1950; Ross, 1951, pp. 82-84, pl. 18, figs. 25, 26, 28-36; Hintze, 1953, pp. 144-147, pl. 20, figs. 2-13). It resembles the Irish species described by Stubblefield in the relatively great width of the fixed cheek at the posterior margin, but differs from all other known species in the subdivision of the occipital ring into three narrow, transverse, convex bands, the presence of the long, upwardly and backwardly directed occipital spine, and the tuberculation on the glabella in front of the occipital ring, the ''basal lobe'' and fixed cheek. The palpebral rim is not preserved, but the broad palpebral furrow is present, and shows the characteristic gentle flexure at about the midlength. At the distal extremity the posterior border widens abruptly, immediately inside the point at which it is crossed by the posterior branch of the suture. A similar structure is present on some of the species described by Hintze — the posterior border curves back distally to join the border of the free cheek.

CAROLINITES sp. ind. 2

Plate 39, figures 7, 12, 13

Material. A single incomplete and exfoliated cranidium (GSC 18568) from the middle Table Head Formation at Table Cove.

Description. This cranidium does not appear to represent the same species as that from Black Cove. The convexity of both glabella and fixed cheek is greater, as seen in both longitudinal and transverse profiles, and the fixed cheek is much wider. Distally the cheek slopes down steeply to the broad, deep palpebral furrow, which is gently curved and runs almost directly backward posteriorly. External surface of glabella in front of occipital ring and fixed cheek bears tubercles which are larger and more widely scattered than in *Carolinites* sp. ind. 1.

A pygidium (Pl. 39, figs. 8, 9) from the same locality and horizon is like that of some species of *Carolinites* (Ross, 1951, pl. 18, figs. 28, 32, 35; Hintze, 1953, pl. 20, figs. 5a, 5b, 9) in outline, prominence of the axis, presence of deep first pleural furrow, but does not exhibit the distally-projecting posterior pleural bands.

Family REMOPLEURIDIDAE Hawle and Corda, 1847

Genus REMOPLEURIDES Portlock, 1843

REMOPLEURIDES PILULUS n. sp.

Plate 39, figures 14-16; Plate 40, figures 5-8

Holotype. GSC 18570, cranidium with exoskeleton from middle Table Head Formation at Table Cove.

Other material. Cranidia from the same locality and horizon as the holotype.

Description. This species is distinguished from *Remopleurides ligulus* Whittington, 1963 (p. 36, pl. 4, figs. 1-10) from the boulder at Lower Head by the much greater convexity which gives it a hemispherical form. In dorsal aspect the cranidium is wider (tr.) across the midpoint of the palpebral lobes, and tapers more rapidly forward to the rounded outline of the tongue. In lateral or transverse profile the greater convexity is readily evident, and in *R. pilulus* the convexity of the glabella between the eye lobes is greater than in *R. ligulus,* while that of the tongue is less. The palpebral rim is extremely narrow, separated from the glabella by the deep palpebral furrow. The external surface is finely granulate, this granulation most evident on the occipital ring and the distal areas of the glabella and tongue, dying out and disappearing in the median part of the glabella. Lateral furrow 1p is not visible, but 2p is a distinct, narrow furrow which curves inward. Lateral furrow 3p is represented by a faint, transversely-ovate smooth depression, situated opposite the anterior end of the palpebral rim and in line (exs.) with the inner part of furrow 2p.

I have examined the type cranidia (GSC 881, a-c) of *Remopleurides affinis* Billings, 1865 (pp. 325-6, fig. 313), from a boulder in the Mystic Conglomerate, Quebec. They are like that of *R. ligulus,* not that of the Table Head species.

REMOPLEURIDES sp. ind.

Plate 40, figures 1-4

Material. Two cranidia (GSC 18572, 18573) from the middle Table Head Formation, 190 feet above the base in the type section.

Description. In dorsal aspect this cranidium appears relatively narrower and longer than that of *R. pilulus,* and both the longitudinal and transverse convexity is much less, so that the tongue curves down in front of the palpebral lobes to become vertical at the anterior margin. This convexity is less than that of *R. ligulus* (compare Plate 40, figure 2, with Whittington, 1963, pl. 4, figs. 7, 8). Thus this cranidium appears to represent a third species, in which the palpebral rim is wider than in *R. pilulus,* and the granulation on the glabella relatively coarser and confined to the distal edges. Muscle areas 1p and 2p appear as narrow, curved, faintly depressed smooth bands.

Genus ROBERGIA Wiman, 1905

ROBERGIA SCHLOTHEIMI (Billings, 1865)

Plate 40, figures 9-12; Plate 41

Billings, 1865, p. 294, figs. 284a, b.
Raymond, 1925, pp. 58-60.

Lectotype (here selected). GSC 694, internal mould of cranidium, from middle Table Head Formation at Pistolet Bay. Paralectotypes: GSC 694a, b, c, d, cranidia from same locality as lectotype; GSC 695, cranidium from middle Table Head Formation at Bonne Bay.

Other material. Raymond had before him specimens collected by A. Hyatt from the middle Table Head Formation at Black Cove and the south side of St. John Island. This species is common only in the highest part of the middle Table Head Formation, from 185 feet above the base to the top, in bed 4 at Black Cove, and the highest beds exposed immediately south of Table Cove. Rare specimens have been obtained from the isolated limestone and exposures on the foreshore south of Table Cove, and in the boulders at Daniel's Harbour.

Description. The cranidium is typical of *Robergia* (Whittington, 1950, pp. 543-544, pl. 71, figs. 1-8; 1959, pp. 428-431, pl. 18, figs. 1-22, 25), displaying the characteristic inflated median outer part of the occipital ring, the subcircular gently inflated lateral glabellar lobe 1p, the three pairs of lateral glabellar furrows, the wide palpebral rim, and the narrow strip surrounding the tongue. On the external surface (Pl. 40, fig. 12) are fine raised lines in a Bertillon pattern. There is a small median occipital tubercle close to the anterior margin, best seen in the small cranidium (Pl. 41, fig. 5). The hypostome of the type species is not known, but I have described that of *R. major* (1959, p. 429, pl. 18, figs. 8-14), which is subsquare in outline, the middle body occupied almost entirely by the large oval areas, the borders narrow, and the anterior wing small. The hypostome (Pl. 41, figs. 3, 4, 7) here attributed to *R. schlotheimi* (it has been found at the type section and at Black Cove, where cranidia and pygidia are relatively abundant) is different in appearance. The outline is elongate-oval, the oval areas raised but occupying less than one-half of the gently convex middle body. There is no border on the curving anterior margin, but laterally there is a shallow furrow separating the middle body from the large, triangular anterior wing. The margin of the latter curves gently to the right-angled tip, which lies above the anterior part of the oval area. The lateral border commences opposite the anterior end of the oval area and is a narrow, convex ridge separated from the oval area by a deep furrow. The posterior border is wider (exs. and sag.), less convex medially and separated from the middle body by shallow furrows. External surface covered by fine, raised lines in a Bertillon pattern, on the anterior part of the middle body running in curves that are convex backward, on the oval area in curves that are convex laterally.

Pygidium subrectangular in outline, convex axis tapering to blunt point and reaching to about half the length (sag.). Pleural region broad and flat, crossed by two low, diagonally-directed ridges (the posterior pleural bands of the first two segments) which run out along the posterior margin of the first two border spines, and are separated from each other and the anterolateral corner by broad, shallow pleural furrows. The first pleural spine is short, situated on the lateral border at about four-fifths the length from the anterior corner. The second pleural spine is much the longest and broadest, and along the posterior margin between the second spines may be seen the blunt points of the third spines, and a median notch. An extremely faint third posterior pleural band runs out to the third pleural spine. Doublure extends under the entire pleural regions to the axial furrow and is flexed up at the tip of the axis. On the external surface fine, closely-spaced lines run diagonally in a wavy course across the pleural regions; on the doublure similar lines run concentrically around the axis, there being a heavier line at intervals.

Discussion. Distinctive of this species are the large, prolonged, second pleural spines of the pygidium, giving it a forked outline. In the type species the outline is subrectangular, the three pairs of pleural spines are approximately equal in length, and the tips lie in a curve that is convex backward. *R. major* has the second pleural spines elongated, but not to the extent that is seen in *R. schlotheimi.* Billings (1865, p. 294) referred to a pygidium but did not figure it, and the type specimen is not preserved. It is described as ovate in outline with five or six well-defined ribs on each side, and appears not to belong to this species. Raymond (1925, p. 59) had only an incomplete specimen of the pygidium, and thought that the elongated pleural spine was the outer one.

Species of *Robergia* are relatively abundant in both North America and Europe, in rocks of approximately Llandeilo and somewhat younger age. The present species appears to be one of the oldest known.

Genus BLOSYROPSIS n. gen.

Type species. Blosyropsis billingsi n. gen., n. sp.

Diagnosis. Cranidium distinguished from *Remopleurides* by the deep pit at the inner end of lateral glabellar furrow 1p, which is connected by a shallow furrow running backward and slightly outward to the distal end of the occipital furrow, and the horizontal border in front of the tongue. Free cheek with narrow, convex border separated from eye lobe by narrow strip, base of genal spine situated opposite midlength of eye lobe, genal spine long, curving, blade-like. Hypostome longer than wide, rectangular in outline, oval areas covering about half the middle body, large anterior wing. Pygidium transversely rectangular in outline, axis extending about half the length, strong postaxial ridge; pleural regions horizontal, composed of three fused pleurae divided by ribs and furrows, the tips extended by short spines. External surface with prominent pattern of closely-spaced fine lines.

Discussion. While the cranidium is most like that of *Remopleurides,* the free cheek and pygidium are more like those of *Robergia* and *Robergiella* (Whittington, 1959, pp. 431-434, pl. 6, figs. 16-33). This latter genus, from the lower Edinburg Formation of Virginia, has a remopleuridid-like cranidium in which the three pairs of glabellar furrows appear as shallow grooves, and a *Robergia*-like free cheek and pygidium. It may be a younger relative of the new genus, exemplifying an evolutionary line intermediate between *Remopleurides* and *Robergia.*

BLOSYROPSIS BILLINGSI n. sp.

Plate 42

Holotype. GSC 18250, incomplete cranidium from 17 feet above base of type section, middle Table Head Formation.

Other material. This species is not uncommon in the lower half of the middle Table Head Formation, from 17 to 155 feet above the base at the type section, where all parts of the exoskeleton except the thoracic pleurae have been found; it is also found in the isolated limestone, at Table Cove, and in the boulders at Daniel's Harbour.

Description. Convex occipital ring transversely oval in outline, sloping forward to deep, straight occipital furrow. In front of here median area of glabella is considerably wider (tr.) than occipital ring, gently inflated, and passes anteriorly into the steeply sloping tongue. Glabella circumscribed by deep palpebral, axial, and preglabellar furrows; in front of the latter is the narrow (sag. and exs.), horizontally-extended, gently convex preglabellar area forming the anterior border. Palpebral rim widest laterally and posteriorly, where it curves down abruptly immediately in front of the occipital ring; anteriorly the rim narrows and dies out at the base of tongue. Lateral glabellar furrow 1p (Pl. 42, fig. 2) is a smooth, diagonally-directed area situated just behind midlength of eye lobe, at inner end descending into a deep, diagonally-directed pit. This pit is connected by a shallower furrow to the outer end of the occipital furrow; between the furrows the basal part of the median area of the glabella is convex, and outside the furrow the median area rises steeply. Lateral glabellar furrow 2p a smooth area, not depressed on the external surface, commencing opposite the anterior part of the eye lobe and curving inward and backward to end approximately in line with the pit of furrow 1p. Lateral glabellar furrow 3p a small, oval smooth area not depressed into the external surface, in line with the inner ends of furrows 1p and 2p. Eye surface (Pl. 42, fig. 10) gently convex, numerous convex facets arranged in vertical lines, prominent external rim of eye lobe separates it from horizontal inner part of cheek. Outer part of free cheek consists of raised gently convex border, continuous with anterior border of cranidium, widest laterally at the base of the blade-like, long genal spine. The posterolateral border is slightly more convex, and ends against the outwardly and slightly backwardly directed posterior branch of the suture. Posterior part of fixed cheek not known. External surface of cephalon, except in deep furrows, traversed by strong, closely-spaced, fine raised lines. These lines run in curves directed concavely forward on the glabella, and continue this direction on the inner part of the free cheek; on the borders they run concentrically, on the upper surface of the genal spine, diagonally. In the midline of the glabella, between the inner end of lateral furrow 2p and the base of the tongue, the lines merge into a low, median ridge (Pl. 42, fig. 2).

Hypostome slightly longer than wide. Middle body gently convex, displaying prominent oval areas which extend from the midlength back to the posterior margin and are closer together posteriorly than anteriorly. Anterior edge of hypostome straight medially, distally curving back where the edge is extended as the triangular, upwardly-directed anterior wing. At the base of this wing is a shallow furrow, inside it a prominent smooth band on the anterolateral and anterior part of the median body. Behind the small shoulder is the narrow lateral border; there is a short posterolateral projection and a wider (sag. and exs.) posterior border. External surface bearing lines similar to those on the dorsal exoskeleton, running in curves deeply concave forward on the middle body, longitudinally on the oval area and borders.

Pygidium with short, prominent convex axis almost semicircular in outline, prolonged backward by postaxial ridge which becomes narrower and lower and disappears just before reaching the posterior margin. Articulating furrow is deep distally, shallower and broader medially, first ring furrow similar though distal parts less deep, second ring furrow extremely fainty indicated. Pleural regions extend out horizontally, transversely directed anterior margin, lateral margin curved convexly outward. These pleural regions divided by gently convex ribs and broad shallow pleural furrows, three of each, the third pair of pleural furrows flanking the postaxial ridge. The ribs appear to represent the anterior pleural bands, and in line with the furrows between are the pleural spines; the first is short, the second much longer, the third as short as the first and close to the midline. External surface (Pl. 42, fig. 15) covered by closely-spaced lines, which run transversely in a wavy course over the pleural regions, and in curves directed convexly forward on the axis.

Discussion. The combination of characters seen in this species is unlike those of any other remopleuridid known to me. It is the typical species of the lower half of the middle Table Head Formation, being replaced in the upper part by *Robergia schlotheimi*. So far these two species have not been found together, the latter being more characteristic of the platy, black limestones of the upper part of the middle Table Head Formation.

Billings (1865, p. 293, fig. 283) described the cranidium of *Remopleurides panderi* from the type section of the middle Table Head, but the syntypes have not been traced in the collections of the Geological Survey of Canada. Raymond identifies this cranidium from both the lower part of the type section and the isolated limestone. These descriptions, and Billings' figure, suggest that this cranidium is the same as that here called *Blosyropsis billingsi*. However, without the syntypes one cannot be sure, and in the interests of nomenclatural stability I prefer to use a new name for this species, which is also the type of a new genus.

Genus EOROBERGIA Cooper, 1953

EOROBERGIA GRANDIS n. sp.

Plate 43; Plate 44, figures 1, 2

Eorobergia sp., Whittington and Kindle, 1963, fig. 2.

Holotype. GSC 18256, incomplete cranidium with exoskeleton adhering, lower Table Head Formation, Pointe Riche.

Other material. Figured material and a few additional scraps from the same locality and horizon as holotype; fragments of pygidium from lower Table Head Formation, type section, 95 feet above the base of bed 3, 10 feet above the base of bed 8.

Description. The cranidium, free cheek and pygidium are extremely like those of the type species *Eorobergia marginalis* (Raymond, 1925, pp. 61-62, pl. 3, fig. 11; Cooper, 1953, pp. 21-22, pl. 8, figs. 1-6) from the Tumbez Formation, equivalent to the basal beds of the Lenoir Limestone (in the restricted sense of Cooper and Cooper *in* Cooper, 1956, p. 72), two miles south of Bluff City, Tennessee. The glabella of the Newfoundland species shows the same sharp flexure (Pl. 43, fig. 6) running inward and forward from the outer, posterior margin of the occipital ring to define a lateral occipital lobe, and the three pairs of lateral glabellar furrows are similar in position and depth. Lateral furrows 2p and 3p are smooth on the external surface, faintly impressed, and a similar smooth, faintly impressed area is seen adjacent to the inner, anterior margin of the lateral occipital lobe — presumably part of the muscle attachment area situated on the outer part of the deep occipital furrow. In both species the eye lobe is of length (exs.) about half that of the cranidium, but the curvature of the palpebral rim of the Newfoundland species is more even than that of the Tennessee species, which is strongly curved in the posterior part. In both species the palpebral furrow is widened posteriorly, and in the Newfoundland species there is a wide, depressed region between the posterior part of the palpebral rim and the gently inflated palpebral lobe. Anterior branch of the suture in *E. grandis* (Pl. 43, figs. 1, 5) runs strongly outward and downward at the edge of the visual surface, then changes course abruptly to run forward and less strongly outward, and as it reaches the horizontal, gently convex border it curves outward and forward to the margin of the border. The two branches meet in the midline at an oblique angle. The posterior branch of the suture (Pl. 43, fig. 6) runs downward and slightly outward beside the visual surface, then at the lower posterior corner turns abruptly outward and runs far out on the cheek before crossing the border. Thus the posterior part of the fixed cheek is a thin, outwardly-projecting strip. Three or four conspicuous pits are present in the anterior border a short distance in front of the preglabellar furrow. Only a fragment of the free cheek is available (Pl. 43, fig. 2), but it shows the broad lateral border defined by a shallow furrow, the narrow posterior border and deeper posterior border furrow, and the long, curving, slim genal spine. Strongly raised anastomosing lines are present on the exterior surface of the exoskeleton except in the furrows, their distribution being shown in Plate 43, figures 1-3. The anastomosing character is best developed on the glabella — on the anterior border the lines run concentrically, on the lateral border and genal spine they zig-zag to give a herringbone pattern. The external surface of the glabella is not granulate as it is in *E. marginalis.*

Pygidium in the two species similar, the tapering, prominent axis defined by deep lateral furrows, the tip sloping steeply but not defined by well marked furrows; first two rings outlined by ring furrows. Pleural regions bearing four pairs of marginal spines which are flat and blade-like, and in *E. grandis* these spines are graduated in size, the second and fourth not markedly smaller than the first and third, as in *E. marginalis.* The anterior band of the first pleura is strongly convex; there is a deep, broad pleural furrow, and a narrow, gently convex posterior band which runs out into the posterior edge of the border spine. Similar bands and an intervening pleural furrow are present on the second pleura, the anterior band of the third pleura marked by a triangular raised area adjacent to the posterior end of the axis. External surface bearing raised lines that run roughly concentrically, with a marked curvature across the spines, giving a herringbone pattern, the flexure in the lines being nearer the outer margin of the spine than the inner, as on the genal spine.

Discussion. E. grandis differs in only minor characters from *E. marginalis,* and is the only other species of this genus known. Material described by Cooper, the originals of Raymond, and additional material collected by F. C. Shaw and me in 1962, show no specimens from Tennessee as large as those from Newfoundland. Accepting the correlations of Cooper (1956), the Tennessee species is slightly younger than that from Newfoundland.

In my arrangement of the remopleuridids (*in* Moore, 1959, pp. 0326-0331) I placed *Eorobergia* in the group including *Richardsonella* because of the divergent anterior branches of the suture, the pits in the anterior border, and the type of the pygidium. If this arrangement represents an evolutionary line, this line leads from *Richardsonella* of the Upper Cambrian through early Ordovician and Canadian forms to *Eorobergia,* the youngest known representative.

Family BATHYURIDAE Walcott, 1886

Genus ACIDIPHORUS Raymond, 1925

Type species. Acidiphorus spinifer Raymond, 1925.
Subjective synonyms. Goniotelus Ulrich, 1927; *Gonotelus* Ulrich, 1932.

Discussion. The type species of *Goniotelus* is *G. perspicator* (Whittington, 1953, pp. 662-663, pl. 68, figs. 1-10) from a boulder of probable Whiterock age in Quebec. I have recently described additional material of the type species from the boulder at Lower Head, together with three additional species from the same horizon (Whittington, 1963, pp. 62-65, pl. 14, figs. 3-12; pl. 15, figs. 1-8; pl. 35, figs. 2, 5, 7, 9). If these species are accepted as belonging within one generic group, then Raymond's species *A. spinifer* belongs within the same group. The generic name for it should be the oldest one available, which is *Acidiphorus.*

ACIDIPHORUS SPINIFER Raymond, 1925
Plate 44, figures 3-16

Raymond, 1925, p. 131, pl. 8, figs. 15, 17.
Whittington, 1953, p. 669, pl. 68, fig. 12.

Holotype. YPM 13028, incomplete pygidium from "*Leperditia* bed at Table Head," that is, from bed 8 of the lower Table Head Formation.

Other material. YPM 13052, incomplete pygidium from "zone 11, Pointe Riche," that is, the higher beds of the lower Table Head Formation at Pointe Riche. YPM 13062, fragments of cranidium and a free cheek, from same locality and horizon. The present investigation has shown fragments of the exoskeleton to be fairly common in bed 8 (from 175 to 400 feet above the base) of the lower Table Head Formation at the type section, and at Pointe Riche.

Description. Cephalon differs from that of *A. rostratus* (Whittington, 1963, pp. 64-65, pl. 14, figs. 10-12; pl. 15, figs. 1-4, 6) in that the glabella is relatively narrower but more convex anteriorly, the frontal lobe being slightly but distinctly expanded. The palpebral lobe is slightly farther out from the axial furrow, and higher, standing above the middle part of the glabella (Pl. 44, fig. 3), and with a less wire-like rim. The free cheek does not exhibit the deep border furrow seen in *A. rostratus.* The sculpture of the external surface is also different — in *A. spinifer* tuberculation is present on the median lobe of the glabella and the cheek adjacent to the eye lobe, elsewhere are anastomosing lines with pits between them. On the lateral part of the glabella inside the eye lobe, both tubercles and lines die out, and there are smooth areas which indicate the presence of lateral glabellar furrows 1p and 2p, but these are less clearly defined than in *A. rostratus.* The lines are conspicuous on the median and steeply sloping part of the frontal glabellar lobe, and are also present on the lateral borders.

Anterior branch of facial suture runs forward in a curve that is convex outward and subparallel to the axial and preglabellar furrows. Anteriorly, the branch runs on to the upper surface of the anterior border, the two branches converging and apparently meeting a short (tr.) rostral suture (Pl. 44, fig. 13). Posterior branch of suture curves downward and outward from the high eye lobe, and crosses the posterior border distally where it is widest. Doublure of free cheek wider than border, posterolaterally with a flexure which lies beneath the flexure of the dorsal surface at the base of the genal spine.

Pygidium triangular in outline, the axis and inner part of the pleural regions prolonged backwards in a stout spine which is directed slightly upward and has a gentle curvature. The spine is of length (sag.) twice that of the remainder of the pygidium. Convex, semicylindrical axis tapering slightly to base of posterior spine, deep articulating furrow and four ring furrows becoming successively fainter backward. Pleural regions slope steeply to flattened, ill-defined, smooth border. Narrow, deep first pleural furrow curves outward and backward immediately behind the facet, and dies out without reaching the margin. Second pleural furrow more backwardly directed, but shorter, faint third furrow. Flattened, outwardly sloping lateral border becomes narrower posteriorly and disappears beneath the base of the posterior spine. External surface of axis bearing irregular, anastomosing lines running in curves convex forward; at the base of the spine the curvature increases and on the spine the lines run longitudinally. Similar lines are present on the outer part of the border, and there are minute pits between them both on the axis and on the borders.

Discussion. Both *A. rostratus* and *A. spinifer* are like *Goniotelina williamsi,* the type species of *Goniotelina* (Whittington, 1953, pp. 663-667), in the outline of the glabella, position and curvature of the eye lobe, form of the genal spine, and of the pygidium. The chief difference between species placed in the two genera is in the much greater convexity of the glabella of *Acidiphorus,* and the expansion of the frontal lobe.

Family ILLAENIDAE Hawle and Corda, 1847

Subfamily ILLAENINAE Hawle and Corda, 1847

Genus ILLAENUS Dalman, 1827

Discussion. In dealing with illaenids from the boulder at Lower Head (Whittington, 1963, pp. 66-69) I referred to recent work and discussed characters used in the taxonomy of this group. In *Illaenus marginalis* the rostral plate (Pl. 47, figs. 8, 10) possesses an axe-shaped flange. This feature, and other characters of the exoskeleton shared by *I. marginalis* and the other four determined species described below, suggest that they should be placed in *Illaenus.* In these five species the doublure of the pygidium has a median projection, which is excavated in a notch where it surrounds the tip of the axis. This type of inner margin of the doublure is present in Scandinavian illaenids, particularly of the *I. sarsi* type (Jaanusson, 1957, p. 110, fig. 14a). The lower and middle Table Head species of *Illaenus* are related to (but in no case identical with) species of the same genus from Lower Head. A relationship between all these species and those from the Lower and early Middle Ordovician of Scandinavia and the East Baltic is evident from the discussions below.

One undetermined hypostome was obtained in the material from the boulder at Lower Head (Whittington, 1963, pl. 18, figs. 4, 7). Hypostomes of both *I. fraternus* (Pl. 45, figs. 14-16) and *I. consimilis* (Pl. 52, figs. 6-13) have been obtained in the present investigation, that of the latter species particularly well preserved and showing the large anterior wing and the notched anterior margin. This notch suggests that, since the hypostome fitted against the inner margin of the cephalic doublure, there was a median projection of this doublure. This projection was probably formed by the axe-shaped rostral flange, as in *I. marginalis* (Pl. 47, fig. 10). Thus the outline of the anterior margin of the hypostome can be used to argue for the presence of a rostral flange, when the rostral plate is unknown. In the subcircular outline of the anterior lobe of the middle body and its convexity, the shape of the posterior lobe, narrow lateral and posterior borders and deep lateral border furrow beside the median lobe, these hypostomes are alike and like that from Lower Head. This similarity in hypostome is suggestive of relationship, and the Newfoundland hypostomes are like those of *I. sarsi* (Jaanusson, 1954, pl. 2, figs. 1, 2) from the Lower Ordovician of Norway and Sweden. Lindström (1901, pp. 57-59, pl. 4, figs. 22-43) described the maculae of illaenid hypostomes. As least in some cases it appears that the external surface of the macula was smooth, the internal surface (as revealed by the internal mould, Lindström, 1901, pl. 4, fig. 37) showing facets which are convex inwards and therefore the mould is pitted. The same structure appears to be revealed by the macula of the hypostome of *I. consimilis* (Pl. 52, figs. 6, 8) as described below. Whether or not the macula should be interpreted as a visual surface is uncertain, but the structure of the exoskeleton over that region does not appear to be the same as that in areas of muscle attachment.

In the taxonomy of the Asaphidae, Jaanusson (*in* Moore, 1959, pp. 0334-0355) used the position of the median glabellar tubercle as a significant character. A glabellar tubercle situated close to the posterior margin is present in the five species of illaenids here determined. Neither Šnajdr (1957) nor Jaanusson (1959, *in* Moore) use the presence or absence of this tubercle, and its position, as a taxonomic character in illaenids, though Jaanusson shows that it is present in *Bumastus* and *Bumastoides* (*in* Moore, 1959, fig. 283, 3a, 6). Further investigation is needed to determine the possible value of this character.

Characteristic of the external surface of the exoskeleton of illaenids are lines which vary in regularity and commonly run subparallel to the margins. These lines are described as ''terrace'' lines by Jaanusson (*in* Moore, 1959, p. 0372) though in the same volume these lines are defined (Harrington, Moore, and Stubblefield, *in* Moore, 1959, p. 0126) as being present on the doublure and border of trilobites. Raymond (1925, p. 105) referred to these lines as ''cracks'' or ''striae,'' but in the species studied here they are raised lines and not grooves or cracks. However, in cross section, they are not symmetrical ridges, but the anterior slope is gentle, the posterior steep. It is the presence of this short, steep posterior slope that demarcates the line. The lines of the doublure are of the same type, but in general are more regular in their course, and more evenly spaced. In this account I have followed Jaanusson, and call the lines on both dorsal exoskeleton and the doublure terrace lines. In addition to bearing terrace lines, the external surface of the exoskeleton may be pitted (Pl. 48, fig. 1). It is also characteristic of these species that the internal mould shows an extremely fine pitting, which may be of two sizes — small pits closely spaced, and larger scattered pits (Pl. 46, fig. 10; Pl. 51, fig. 11; Pl. 54, fig. 5). This pitting is the reflection of granulation on the inner surface of the exoskeleton (Pl. 45, fig. 19; Pl. 68, fig. 9). This granulation may be on the inner surface not only of the dorsal exoskeleton, but also of the doublure. When present on the inner surface the granulation may not be reflected on the outer surface, in the same way that terrace lines may be present on the outer surface, but are either faint or absent on the inner surface (Pl. 45, fig. 19; Pl. 46, fig. 10; Pl. 54, fig. 5). The sculture of the external surface must therefore be described from both surfaces of the exoskeleton or the counterpart moulds. Reference to the internal mould alone may be misleading, e.g. pitting is present in the internal moulds of many species illustrated by Šnajdr (1957), but the nature of the external surface of the exoskeleton is not clearly shown.

ILLAENUS FRATERNUS Billings, 1865
Plate 45; Plate 46, figures 1-5, 6, 8, 10

Billings, 1865, pp. 276-277, fig. 262a, b.
Raymond, 1925, p. 105.

Lectotype (here selected). GSC 665e, cranidium, almost entirely exfoliated, original of Billings, 1865, figure 262a, from the lower Table Head Formation, exposed on the shore north of the lighthouse at Pointe Riche. Paralectotypes: GSC 665a, free cheek; GSC 665b, pygidium; GSC 665c, d, internal moulds of two cranidia; GSC 665, poorly preserved complete specimen apparently showing 9 thoracic segments; all from same locality and horizon as the lectotype.

Other material. Raymond described material only from Pointe Riche, whereas this species was found in the present investigation only in the type section, in bed 8 of the lower Table Head Formation, from 140 to 500 feet above the base. Specimens were most abundant in the middle part of this range.

Description. The strongly curved profile of the cephalon, in both dorsal and lateral aspects, and the lack of the projecting anterior border, distinguish this species from the other two in the lower Table Head Formation. The glabella is gently convex, defined by deep, subparallel axial furrows which extend forward a short distance in front of the eye lobe, and die out abruptly; on the internal mould the anterior part of the furrow forms a crescent-shaped depression, the lunette. There is no median glabellar depression, and the glabellar tubercle (Pl. 45, fig. 4) is situated close to the posterior border, the transverse line passing through it lying behind the eye lobe. Palpebral lobe without rim and not separated from fixed cheek by change in slope. Posterior branch of facial suture runs straight backward and slightly outward. Anterior branch runs at first straight forward, then curves gradually in to reach the anterior margin outside the projected line of the axial furrow. Anterior margin of cranidium flexed sharply to form doublure, rostral plate not known. Genal angle of free cheek broadly rounded, shallow, oblique notch in lateral margin approximately in line with anterior edge of eye lobe (Pl. 45, figs. 17, 18, 20). External surface traversed by raised lines which run subparallel to the posterior and anterolateral margins; on the free cheek outside the eye lobe, these two sets of terrace lines meet at acute angles. On the internal surface are widely scattered granules (Pl. 45, fig. 19) which are reflected as pits in the external surface of larger specimens.

Axis of pygidium extends about half the length, tapering rapidly and gently convex. Pleural regions bent down distally, so that posteriorly they slope vertically. Broad doublure (Pl. 46, figs. 6, 8) extends forward medially as a tongue, which is deeply excavated where it surrounds the posterior part of the axis, the lateral part extending beneath the axial furrow as a sharp projection. Terrace lines run transversely on axis and inner part of pleural regions, ending against terrace lines which run on outer part of pleural regions subparallel to margin. Doublure traversed by terrace lines running subparallel to the margin, and exhibiting a low median ridge. On internal surface scattered granules amid extremely fine granulation (Pl. 46, fig. 10), terrace lines of doublure not visible. External surface of large specimens may show pits corresponding to larger granules.

From a lens of lime-sand approximately 350 feet above the base of unit 8 of the lower Table Head Formation (Whittington and Kindle, 1963, fig. 2) seven species of trilobites were obtained, the only illaenid present being *I. fraternus*. The single specimen of the hypostome (Pl. 45, figs. 14-16) obtained at this locality may thus be assigned with confidence to this species. The wings and anterior border are not complete, but the middle body, lateral borders, and position of the maculae are much like those in hypostomes of *Illaenus* portrayed by Lindström (1901, pl. 4, figs. 24, 30, 36, 38). It is also like the hypostome here assigned to *I. consimilis* (Pl. 52, figs. 6-13). Anterior lobe of middle body is subcircular in outline, moderately convex, separated by deep furrow from narrow lateral border. Middle furrow runs inward and backward from the deep part of this lateral border furrow, and the two furrows unite medially. Posterior lobe of middle body is gently convex, crescent-shaped, and the small, oval raised macula is situated adjacent to the inner part of the middle furrow. Posterolateral border narrow, posterior border not preserved. Anterior wing is evidently large and curves upward and outward.

Discussion. In outline and convexity of cephalon and pygidium, position and length of axial furrows, shape of pygidial doublure, and arrangement of lines on the external surface, this species resembles *I. tumidifrons* from the boulder at Lower Head (Whittington, 1963, pp. 69-71, pl. 15, figs. 9-13; pl. 16). The glabella of *I. fraternus* is less convex than that of *I. tumidifrons,* the cephalon less strongly curved in lateral profile, and there is no notch in the lateral margin of the free cheek of *I. tumidifrons.*

The smallest cranidium (Pl. 45, figs. 11-13) has the axial furrows extending farther forward than in larger specimens, and in this region they are widely divergent, suggesting that the glabella is widest anteriorly. Small cranidia appear more convex in both dorsal and longitudinal profiles, and the glabellar tubercle is prominent on the external surface. The raised, smooth region of the posterior part of the right fixed cheek of this specimen is unusual, perhaps the result of injury.

ILLAENUS MARGINALIS Raymond, 1925

Plate 46, figures 7, 9, 11, 12;
Plate 47; Plate 48, figures 1-6, 8, 10

Raymond, 1925, p. 109, pl. 7, figs. 8, 9.

Lectotype. YPM 13045, incomplete and exfoliated cranidium, original of Raymond's figure 8, from Pointe Riche.

Other material. YPM 13038, exfoliated pygidium from same horizon and locality as the lectotype. This species is common in bed 8, from 0 to 500 feet above the base, of the lower Table Head Formation at the type section, and a few fragmentary specimens which may represent this species occur in bed 3 of the same section. It is also common at Pointe Riche.

Description. Characteristic of this species is the relatively wide (tr.) and short (sag.) cephalon and pygidium (the former with a narrow, gently convex border around the margin), the relatively wide axis and steeply bent down outer parts of the pleurae. It appears to belong in the *Illaenus sarsi* group of Jaanusson (1957, p. 110), and *I. incisus* Jaanusson, 1957, has a similar border around the cephalon. *I. marginalis* is like *I. tumidifrons* (Whittington, 1963, pp. 69-71, pl. 15, figs. 9-13; pl. 16; text-fig. 4a-c) from the boulder at Lower Head in the form of the rostral plate with its axe-shaped flange (Pl. 47, figs. 8, 10), and the pygidial doublure with its tongue that embraces the tip of the axis (Pl. 48, fig. 10). The axis in *I. marginalis* is much broader and lower than in *I. tumidifrons,* and on the cephalon the axial furrows converge forward to die out about in line with the most anterior part of the eye lobe. The latter is large, situated close to the posterior margin, the palpebral lobe at almost the same height as the median part of the glabella (Pl. 47, figs. 4, 6), so that the cheek slopes gently inward from the palpebral lobe to the axial furrow. The cephalic doublure is moderately wide (sag. and exs.) anteriorly, laterally (Pl. 47, fig. 9) it is bent upward to lie close beneath the dorsal exoskeleton of the free cheek, and at the genal angle is the vincular furrow. The latter is crossed transversely by ridges and grooves.

Ten thoracic segments and a pygidium are articulated in one specimen (Pl. 46, figs. 11, 12). The outer parts of the pleurae are bent to slope steeply down, and correspondingly the margin of the inner part of the pleural region of the pygidium runs transversely, then curves abruptly through an angle of about 80° so that the facet runs backward and outward. During enrollment the tips of the pleurae and the posterior end of the facet lay in the vincular furrow, the end of the facet at the anterior end of the furrow. The posterolateral margins of the pygidium are curved to fit approximately the curve of the inner margin of the cephalic doublure, and presumably the doublures of cephalon and pygidium were in contact during enrollment. External surface of the cephalon with a slight depressed median region extending from between the eye lobes to slightly in front of them, this region impressed by irregular, large pits (Pl. 48, fig. 1). Pygidium bears prominent impressed lines running in inverted "V" on the axis and inner part of the pleural regions. On the doublure of cephalon and pygidium prominent terrace lines run subparallel to the margins. On internal surface of exoskeleton are granules of two sizes, small ones closely spaced and scattered larger ones. The tiny pits visible in the external surface correspond to these larger granules.

Discussion. Raymond identified this species from beds of middle Table Head age but I have found no trace of it in these younger beds. Two types of cephala (*Illaenus* sp. ind. 1 and *I.* sp. ind. 2), each having a rim around the margin of the cephalon, were described from Lower Head (Whittington, 1963, pp. 73-74, pl. 19, figs. 1-9). Neither of these cephala is at all like *I. marginalis.*

A pygidium with three thoracic segments (Pl. 46, fig. 9) shows an unusual feature in that the outer part of the pleura of the third segment from the posterior is much longer than that of the two succeeding segments. Apart from this, the segments and pygidium are like those of *I. marginalis.*

ILLAENUS ALVEATUS Raymond, 1925

Plate 48, figures 7, 9, 11-15; Plate 49, figures 1-10, 12, 13;
Plate 68, figure 9

Raymond, 1925, pp. 109-110, pl. 7, fig. 5.

Holotype. YPM 13058, incomplete and largely exfoliated cranidium, from Pointe Riche.

Other material. YPM 13034, small piece of limestone containing cranidium and adjacent to it six thoracic segments and a disarticulated, incomplete pygidium, from "zone 10," Gargamelle Cove on the east side of the Pointe Riche peninsula. These beds are in the upper part of the lower Table Head Formation (Schuchert and Dunbar, 1934, p. 65, fig. 4). In the recent investigation this species was found in bed 8, type section of the lower Table Head Formation, being most abundant in the middle part of bed 8, and in higher beds the fragments obtained are doubtfully referred to this species.

Description. This species is distinguished by the longitudinal profile of the cephalon, which is steeply curved down and has a prominent forwardly projecting anterior border. In the margin of the free cheek there is an obliquely angulate notch (Pl. 49, figs. 10, 13) and the glabellar tubercle is situated close to the posterior margin and most evident in internal moulds (Pl. 49, fig. 7; Pl. 68, fig. 9). These characters distinguish this species from *I. marginalis,* from which it also differs in the outline of the cranidium in dorsal view (less strongly curved transversely, compare Pl. 48, figs. 1 and 9), the downward slope of the fixed cheek to the palpebral lobe, which stands well above the level of the median part of the glabella, and the less strongly convergent axial furrows (compare Pl. 49, figs. 3, 6, 7, 9, with Pl. 47, figs. 1, 4-6). In internal moulds the most anterior part of the axial furrow shows a wide depressed portion anteriorly, the lunette. In both species there is a median depressed region in the glabella, in *I. alveatus* it is oval in outline, extending from a short distance in front of the median glabellar tubercle to a point in front of the lunettes. In the holotype the anterior border of the cranidium projects farther forward than in other specimens (compare Pl. 48, fig. 7 with Pl. 48, fig. 14, and Pl. 49, figs. 8, 12), and the longitudinal profile appears more strongly curved because the exoskeleton is bent downward behind the transverse fracture which runs across the posterior part of the cranidium. The posterior branch of the suture runs straight backward and outward from the palpebral lobe, which is situated close to the posterior margin. The anterior branch runs at first almost straight forward, then curves gently inward and runs on to the anterior border. The rostral suture runs along the doublure a short distance in from the margin of the border (Pl. 48, fig. 15). The rostral plate is unknown. Genal angle rounded, posterolateral part of free cheek projects slightly behind remainder of cephalon, anterior cephalic border apparently dies out as it passes on to the free cheek.

Raymond (1925, p. 110) described but did not illustrate the segments and pygidium shown in Plate 49, figures 1, 4. The pygidium is relatively wider (tr.) and shorter (sag.) than that of *I. marginalis;* the tongue of the doublure is wider and less deeply indented medially. The thoracic segments are like those of *I. marginalis* in that the outer parts of the pleurae are bent steeply down, and the anterior margin of the pygidium is angulate to conform with the shape of these pleurae.

External surface not well preserved since most specimens are partly or wholly exfoliated. The depressed median region of the glabella is crossed by 3 or 4 narrow grooves and similar grooves run in an inverted "V" on the axis of the pygidium. Elsewhere the dorsal exoskeleton is pitted, with terrace lines on the borders and margins, and on the doublure. The inner surface is granulated (Pl. 68, fig. 9), large granules being scattered amid minute, closely-spaced granules.

Discussion. Trilobites are abundant only in lenses of lime sand in bed 8 of the lower Table Head Formation at the type section. In some cases these layers have yielded both *I. marginalis* and *I. alveatus,* in other cases they have yielded one or the other species, and *I. alveatus* was not found in the exposures north of the lighthouse at Pointe Riche. Thus these illaenids occur sporadically, and the stratigraphic range represents the accidents of collection and preservation rather than true distribution. *I. fraternus* occurs in the same layers with these two species, but is a quite distinct type. Some layers have yielded all three species, some one, others two. It is possible that *I. marginalis* and *I. alveatus* represent sexual dimorphs of one species.

At 280 ft. above the base of bed 8 of the lower Table Head Formation, all three species mentioned above are present, and in addition a fourth type of cranidium (Pl. 49, figs. 11, 14, 15). In dorsal and anterior aspect this cranidium is most like that of *I. alveatus,* but is distinguished from the latter by the convex outward curvature of the anterior branches of the facial suture, and the narrow anterior border which does not project. In addition, the curvature of the longitudinal profile is greater. Whether or not this cranidium represents a distinct fourth species is uncertain.

ILLAENUS CONSIMILIS Billings, 1865
Plates 50, 51, 52

Billings, 1865, pp. 277-278, fig. 263a, b, c; pp. 331-332, fig. 317.
Raymond, 1925, p. 105.

Lectotype (here selected). GSC 663, exfoliated and incomplete cranidium, original of Billings' figure 263a, 263c, from the middle Table Head Formation at the type section. Paralectotypes: GSC 663h, partly exfoliated pygidium, original of Billings' figure 263b; GSC 663 i, free cheek, possibly original of Billings' figure 317; GSC 663a, c, cranidia; GSC 663j, internal mould of pygidium; GSC 663b, crushed and disarticulated entire specimen, showing the cephalon and pygidium, and parts of only seven thoracic segments; all from same locality and horizon as the lectotype.

Other material. Second most abundant species from 50 to 190 feet above the base of the middle Table Head Formation in the type section; also common at Table Cove and in the isolated limestone.

Description. Cephalon of length (sag.) about one-third maximum width, curvature of profile in dorsal and lateral aspect moderate. Axial furrows broad and shallow, extending forward to a point about opposite the anterior end of the eye lobe and dying out. On the external surface this anterior part of the axial furrow forms a smooth, oval impression, which in the internal mould is the crescentic depression of the lunette. Glabella gently convex, median tubercle close to posterior margin, no median depressed area. Large eye lobe situated far out on cheek and close to posterior margin, palpebral lobe without rim, forming continuous slope with inner part of fixed cheek, this slope curving gently inward toward axial furrow. Posterior branch of suture runs outward and slightly backward. Anterior branch of suture runs forward and curves gently inward, reaching anterior margin at a point in a line (exs.) lying about midway between axial furrow and palpebral lobe. Free cheek is prolonged back at genal angle in a rounded flap-like form, there is an obliquely angulate notch in the lateral margin, and in front of this notch the marginal rim runs inward and forward around the cranidium. Doublure (Pl. 51, fig. 10) curled under lateral border and extending beneath flap-like part of free cheek. Rostral plate unknown. Vincular furrow situated close to inner margin of doublure of free cheek, in form of a sharp flexure and without transverse ridges and grooves.

Several examples of the isolated hypostome (Pl. 52, figs. 6-13) occur 90 feet above the base of the type section, at Table Cove and in the isolated limestone, at all of which places this species is relatively abundant. Middle body divided by shallow middle furrows into a subcircular, convex anterior lobe and a gently convex, crescentic posterior lobe. At maximum width of middle body, and at outer end of middle furrow, lateral border furrow is extremely deep, becoming shallower posterolaterally, but defining a narrow, raised, lateral and posterolateral border. At the posterolateral margin the steep outer edge of this border is extended in a triangular, vertically-directed posterior wing (Pl. 52, fig. 7). Anteriorly and anterolaterally the margin of the middle body is ill defined, for it merges with a gentle change of slope into the large upward and outwardly extending anterior wing. This wing is quadrangular in shape, the two wings meeting anteriorly so that the anterior margin of the hypostome is broadly notched. This notched anterior margin is the sutural margin, and would presumably fit against the projecting rostral flange and adjacent parts of the doublure of the free cheeks. Macula conspicuous, situated adjacent to inner part of middle furrow, a gently convex, transversely ovate area, sloping most steeply on the anterior side. On the external surface the macula appears smooth (Pl. 52, fig. 8), but on the internal mould the sloping anterior face is impressed by closely spaced pits. This structure is like that described by Lindström (1901, pp. 57-59, pl. 4, figs. 33, 37).

External surface of cephalon traversed by raised lines, subparallel and occasionally branching, running in curves parallel to the anterolateral and anterior margins. These lines do not extend on to the flap-like part of the free cheek or across the lunette, and are not present on the anterior part of the glabella on the steeply sloping part of the cranidium (Pl. 51, fig. 2). This smooth area is circular, and behind it, situated a short distance in front of, and proximally to, the lunette, is a second smooth, oval area (Pl. 50, fig. 13), which may represent one of the glabellar muscle areas. On the marginal rim and doublure the lines are closer together and branch less frequently. In cross section the lines inside the borders are seen to be wave-like in form, the anterior slope gentle, the posterior slope extremely steep (Pl. 51, fig. 9). These lines are not "cracks" as Raymond called them, and are reflected less strongly on the inner surface of the exoskeleton. In addition, the internal mould shows scattered large pits, and closely spaced small pits (Pl. 51, fig. 11). This pitting reflects granulation on the inner surface of the exoskeleton (Pl. 51, fig. 9).

Pygidium of width more than twice length (sag.), axis gently convex, pleural regions curve down to slope steeply distally. Axis of width at anterior margin about one-third maximum width of pygidium, ill-defined, tapering rapidly and extending to about half the length. Anterior margin of pleural region runs straight out before being flexed sharply back at slightly more than half the width. Posterolateral margin evenly curved. Broad doublure extended by short tongue (which is notched medially) around tip of axis, faint median ridge. On external surface lines similar to those of cephalon, the steep slope facing posteriorly, widely spaced and irregularly branching, running in curves convex forward across the axis, on the pleural regions subparallel to the posterolateral margin. The lines are best developed on the axis and lateral parts of the pleural region, absent in the median area. On the doublure the lines are closely spaced and more regular. Internal moulds display pitting similar to that of the cephalon.

Discussion. The size series of cranidia (Pl. 50; Pl. 51, figs. 1-8) shows the greater convexity of the small sizes — not only the longitudinal profile, but also the posterior part of the glabella and fixed cheek. The glabella appears narrower, the eye lobe large and far out. As size increases, the convexity is reduced, and axial furrows become more obviously forwardly converging.

In a great many characters this species resembles *Illaenus fraternus* from the lower Table Head Formation — nature of the axial furrows, position of the glabellar tubercle, lack of a median depressed area in the glabella, course of sutures, shape of free cheek and particularly in the presence of the notch in the lateral margin, form of pygidium and doublure. These species, though they may be related, are readily distinguished. *I. consimilis* is a less convex species, with a relatively wider cephalon and pygidium, the arrangement of the lines on the external surface is different, and there are not two sets of lines on the free cheek meeting at an acute angle. Resemblances between *I. consimilis* and *I. marginalis* or *I. alveatus* are less; the strongly raised eyes and rapidly converging axial furrows distinguish *I. marginalis*, for example, as does the prominent anterior border of the cephalon of *I. alveatus*.

This species resembles the Swedish *Illaenus crassicauda* (see Jaanusson, 1954, pp. 573-574, text-figs. 4, 17, pl. 1, figs. 1-7), particularly in the size of the eye lobe, the profile in anterior view, and the type of pygidial doublure. The hypostome is like that of the related species *I. sarsi* (Jaanusson, 1954, text-figs. 7a, 9a, pl. 2, figs. 1, 2) except that the anterior margin is not transverse, but deeply notched, presumably in order to fit against the flange of the rostral plate. The Swedish species mentioned do not have the notch in the lateral margin of the free cheek, but it is present in the related *I. incisus* (Jaanusson, 1957, pl. 7, fig. 2). The Swedish species mentioned are from the upper part of the Lower and the Middle Ordovician.

ILLAENUS GELASINUS n. sp.

Plate 53; Plate 54, figures 1, 5

Holotype. GSC 18307, partly exfoliated cranidium from 90 feet above the base of the middle Table Head Formation, type section.

Other material. This species is much less common than *I. consimilis,* and has beeen found at one level in the type section of the middle Table Head Formation, in the exposures south of Table Cove, the isolated limestone, and the boulders at Daniel's Harbour.

Description. Axis of cephalon gently convex, defined by "S"-shaped axial furrows which are far apart at the posterior margin, but curve inward to the crescentic impressions of the lunettes. These latter are situated relatively far back, in the same transverse line as the posterior part of the eye lobe, and in front of them the glabella is not defined. Cephalon curves steeply down anteriorly, so that the anterior part overhangs the low, narrow rim that runs along the cephalic margin. Posterior margin of cheek runs almost directly outward to the rounded genal angle, which is about 90°. Eye lobe relatively small, situated far out and at two-thirds the length of the cephalon; posterior branch of suture runs outward and backward so that a long projection forms the most posterior part of fixed cheek. Anterior branch of suture runs forward and curves slightly inward to the margin. The course of the sutures and the genal angle give the free cheek a distinctive subquadrangular outline. Rostral plate and hypostome unknown. External surface of cephalon (Pl. 54, fig. 1) traversed by irregular wavy lines running subparallel to the anterior and lateral margins, shallow pitting between the lines. Internal moulds show the granulation on the inner surface of the exoskeleton — small granules closely spaced, and much more widely spaced larger granules. On the doublure the terrace lines are not wavy and are placed close together. Three pairs of smooth areas on the glabella (Pl. 54, fig. 1) probably represent areas of muscle attachment. On the internal mould only the first pair of muscle areas may appear as faintly depressed regions (Pl. 53, figs. 1. 7).

The pygidium that occurs at the same localities as the cephalon has a similar external sculpture of the exoskeleton. Axis relatively narrow, tapering rapidly, low convexity. Anterior margin of pleural region is transverse for over half the width, the outer part curving backward. Thus the pleural regions are divided into an inner horizontal part and an outer, gently curved-down portion, and the convexity of the entire pygidium is low. Doublure broad, extending in to the margin of the horizontal inner part of the pleural regions, behind the axis a very slightly projecting portion is excavated medially, and there is a low median ridge in the external surface. Doublure traversed by terrace lines, and internal surface of exoskeleton (Pl. 54, fig. 5) bearing granulation similar to that on the cephalon.

Discussion. The smallest cranidium (Pl. 53, figs. 9-11) shows the ''S''-shaped, convergent axial furrows, and is like larger cranidia except that the convexity is slightly greater, notably that of the axis.

The profiles of the cephalon in dorsal and lateral aspect, the short (exs.), ''S''-shaped axial furrows, the relatively small eye lobe, and the shape of the free cheek distinguish this species from *I. consimilis.* The outline and low convexity of the pygidium also distinguish it. These features also combine to distinguish *I. gelasinus* from the species in the lower Table Head Formation, and the projection of the doublure behind the axis is less prominent, and with shorter lateral points, than in any of the other species described.

ILLAENUS sp. ind. 2

Plate 54, figures 4, 6, 7

Discussion. One cranidium from the isolated limestone is quite different from *I. consimilis* and *I. gelasinus* in the outline in dorsal and lateral aspect, in the deep, straight axial furrows, which converge slightly forward, ending in well-marked, oval lunettes, the small palpebral lobe, placed far back, and the markedly inward convergence of the anterior branches of the suture. The cranidium is exfoliated, only a small fragment of the exoskeleton being present adjacent to the anterior branch of the suture on the left side. Here the external surface is seen to be impressed by close-spaced pits, a sculpture not seen in any other species from the Table Head Formation.

This cranidium is like that of *I. fraternus* from the lower Table Head Formation, but both the dorsal and lateral profiles are different, and the external surface apparently lacks the terrace lines but is deeply pitted.

ILLAENUS sp. ind. 3
Plate 54, figures 2, 3, 8-11

Description. Two examples of an illaenid pygidium have been obtained from the exposures of the middle Table Head Formation on the foreshore south of Table Cove. The first (Pl. 54, figs. 2, 3, 10) differs considerably in outline and convexity from that of *I. consimilis* (Pl. 52, figs. 1-5) and is relatively larger and more convex than that of *I. gelasinus* (Pl. 53, figs. 13-18). The specimen is almost entirely exfoliated, and the external surface was apparently traversed by raised lines, but the sculpture cannot be seen in detail. The second example (Pl. 54, figs. 8, 9, 11) appears from the general form to represent this species, though the convexity in longitudinal aspect appears different, presumably because the dorsal exoskeleton is broken away to reveal the doublure. The latter is wide, with a low projection reaching forward medially behind the axis and a low median ridge. The projection is broken from the remainder of the doublure, but the tip appears to be clearly preserved, and shows a double scalloping — so that there are two small lateral projections as well as a median one. In this respect this doublure differs from any of the other species described from the Middle Table Head Formation, and is like that of *Illaenus sinuatus* Holm, 1886 (p. 105, fig.; cf. Jaanusson, 1957, fig. 14D), from early Llanvirn limestones of the east Baltic.

Illaenid? pygidium
Plate 67, figure 11

Discussion. This single example, from beds probably in the upper half of the middle Table Head Formation at the type section, is gently convex with a flattened peripheral region. The articulating furrow shows that the axis is wide at the anterior margin, occupying one-third the total width, but behind this point the axis is barely indicated. The width of the axis suggests that this is an illaenid pygidium, though the axis is wider than that of *Illaenus gelasinus* n. sp. (compare Pl. 67, fig. 11 with Pl. 53, figure 17). The identification of this specimen is thus uncertain.

Family SCUTELLUIDAE Richter and Richter, 1955

Genus BRONTEOPSIS Nicholson and Etheridge, 1879

BRONTEOPSIS sp. ind.

Plate 55, figures 1, 4

Bronteopsis scotica, Raymond, 1925, p. 69.

Material. A single incomplete cranidium from middle Table Head Formation, Dominion Iron and Steel Company Quarry at Aguathuna, Port au Port Peninsula. Gray, thin-bedded limestones at this locality yielded to Schuchert and Dunbar specimens of *Ampyxoides semicostatus, Stegnopsis huttoni* and the holotype of *Peraspis lineolata,* and there seems no doubt of their age.

Description. Posterior one-third of glabella parallel-sided, axial furrow deep and narrow in front of occipital ring, latter short (sag. and exs.) and defined by broad shallow furrow. Anterior part of glabella widens gradually, axial furrow shallower and sinuous, swinging out beside lateral lobes 2p and 3p, curving in opposite lateral furrow 3p, and running forward and outward to bound frontal lobe which is widest part of glabella. Outer part of occipital furrow slightly broader and deeper than median part, smooth on external surface. Lateral glabellar furrow 1p a depression in margin of glabella at point where axial furrow starts to swing outward, a shallow branch directed inward and forward, a second shallow branch directed inward and backward; smooth on external surface. Lateral furrows 2p and 3p are subcircular, shallow depressions, situated about one-third of the way across the glabella, and at an approximately equal distance from each other and lateral furrow 1p. Furrow 3p is connected by a faint, transversely directed depression to the axial furrow. In anterior part of frontal lobe, a shallow median depression runs from the anterior margin to about the midlength of the frontal lobe and dies out. Preglabellar furrow extremely narrow as is the anterior border. Only the inner part of the fixed cheek preserved, gently convex, most strongly so adjacent to the posterior part of the glabella. Prominent eye ridge runs inward and forward to reach the axial furrow in line with lateral glabellar furrow 2p. Eye lobe evidently situated centrally on the cheek, far from the glabella. Lateral muscle impression (of Šnajdr, 1960, text-fig. 2) a small crescentic smooth area adjacent to the axial furrow immediately in front of the occipital furrow, and extremely faintly impressed. External surface bearing irregular, anastomosing fine raised lines, which on the glabella run subparallel to the margins, on the cheek is concentric circles around the eye lobe. Small median occipital tubercle beside occipital furrow, impressed by four tiny pits arranged in a square (Pl. 55, fig. 4), like those seen in *Raymondaspis reticulatus* n. sp.

Discussion. Raymond considered this cranidium identical with that of *B. concentrica* (see Skjeseth, 1955, pp. 16-17, pl. 5, figs. 1-3, 5, text-fig. 1), a species considered by Skjeseth to be identical with *B. scotica* (see Whittington, 1950, pp. 544-547, pl. 71, figs. 9-12, text-fig. 4). The cranidia are similar, but that from Newfoundland has the frontal glabellar lobe relatively narrower (tr.), and the eye lobe is apparently situated more centrally on the cheek. There is a considerable resemblance between the Newfoundland specimen and the holotype of *B. holtedahli* Skjeseth, 1955 (pp. 17-18, pl. 5, fig. 4) from a horizon of approximately the same age in Norway.

Skjeseth (1955, pp. 16, 18) regarded the V-shaped lateral glabellar furrow 1p as two separate furrows which run together as they reach the margin of the glabella. In 1950, I interpreted this impression as that of a single furrow, 1p, and this is accepted by Šnajdr, 1960.

Sinclair (1949) described species of the younger genus *Eobronteus,* and the cranidium differs from that of *Bronteopsis* in that the glabella expands much more rapidly forward, the eye ridge is much less conspicuous, but the lateral muscle impression is larger and more distinct.

Genus RAYMONDASPIS Přibyl, 1949

Discussion. Since my discussion (Whittington, 1950, pp. 549-550) of the type species, Skjeseth (1955, pp. 20-21, pl. 4, figs. 2, 4-9; pl. 5, figs. 6, 8) has described additional material and I here accept his view that American species such as those described below are congeneric with the Swedish species. I recently advocated (Whittington 1963, p. 83) that the Styginidae should be merged with the Scutelluidae. *Raymondaspis,* like *Bronteopsis,* shows many scutelluid family characters: the three pairs of glabellar furrows, the first having two divergent branches; the lateral muscle impression; the position of the eye lobe; the course of the sutures and shape of the rostral plate and hypostome; the radial arrangement of pleural ribs (in the transitory pygidium of *Raymondaspis*) and the presence of the postaxial ridge.

RAYMONDASPIS RETICULATUS n. sp.

Plate 55, figures 2, 3, 5-9; Plate 56, figures 1-10;
Plate 57; Plate 58, figures 1, 7

Holotype. GSC 18318, incomplete cephalon from middle Table Head Formation, exposures on foreshore south of Table Cove.

Other material. One of the four most abundant species in the lower 200 feet of the middle Table Head Formation at the type section; present in the isolated limestone, at Table Cove, and in boulders at Daniel's Harbour.

Description. No complete specimen is known, but the cephalon and pygidium are exceedingly like those of *R. gregarius* (Raymond, 1920, pp. 283-284; 1925, pp. 69-70, p. 3, figs. 12-14; Cooper, 1953, pp. 24-25, pl. 9, figs. 1-7, 12-16), and Raymond included the Newfoundland material in his species, which is founded upon specimens from the lower Edinburg Formation of Virginia. Raymond (1925, p. 70) considered that the Newfoundland specimens had "the cranidium a little shorter and broader, the posterior part of the glabella a little wider, and a slightly shorter axial lobe on the pygidium." These distinctions are not readily apparent, but the Newfoundland specimens appear to have the glabella expanded slightly less across the frontal lobe, which is less inflated and has a shallow pit in the anterior margin in the midline. The pyigidium has the axis on the external surface (Pl. 57, fig. 3) clearly terminated, and the postaxial ridge is barely, if at all, visible, as in the Virginia specimens, though it is present on internal moulds (Plate 57, fig. 13). Comparisons are difficult because of the incompleteness of the material so far described from Virginia. The exoskeleton of the Newfoundland species is well preserved, and reveals many morphological details not previously observed in species of this genus:

Glabellar muscle areas (Pl. 55, fig. 9; Pl. 56, figs. 6, 7) include the broad, flat-based area of the outer part of the occipital furrow, outlined on the posterior side by a steep slope down from the ring. Lateral glabellar furrow 1p is V-shaped, smooth on the external surface, and lightly impressed. The posterior, inwardly and backwardly directed branch of the "V" is the larger and more impressed part of this area. In front of here and adjacent to the axial furrow, the external surface is smooth, and on some specimens small, circular, lightly impressed areas represent lateral furrows 2p and 3p, the latter situated behind the greatest width of the glabella. The faint anterior pit is in the axial furrow opposite the widest part of the frontal lobe. The lateral muscle area is smooth, crescentic, lightly impressed, stiuated on the steep slope of the fixed cheek adjacent to the axial furrow and between the levels of the occipital and lateral 1p furrows. In this region the axial furrow is narrowest and deepest.

The eye lobe (Pl. 56, fig. 6; Pl. 57, fig. 12) shows the palpebral lobe to be circular in outline, almost completely circumscribed by a suture line so that it is connected to the fixed cheek only by a narrow, steeply sloping band on the inner side. The gently convex visual surface extends around the eye lobe from one margin to the other of this narrow band; thus there are facets directed not only forward, outward and backward, but also inward and forward, and inward and backward. Both anterior and posterior branches of the suture are widely divergent, the anterior branches joining in a smooth curve along the anterior margin of the cephalon, the posterior branches reaching the margin at about two-thirds the width of the cheek from the axial furrow. The cheek is divided into a convex inner and a concave, gently sloping outer part, the line between them being the paradoublural line. The doublure (Pl. 57, fig. 9) is horizontal in the outer part, the inner part curled up vertically. Anteriorly, it is crossed by inward and backwardly directed connective sutures that lie on the projected line of the axial furrows and isolate the rostral plate. The hypostome is shield-shaped, with lateral and posterior borders of similar width, the shoulders projecting. Gently convex middle body subdivided by diagonal, shallow middle furrows; crescentic posterior part of middle body of length (sag.) about one-third of remainder of middle body. Adjacent to the tip of this crescentic portion of the middle body (Pl. 55, figs. 2, 7, 8), at the inner end of the middle furrow, is a smooth area, the macula, on which is a prominent tubercle. The external surface of this tubercle appears to be smooth. Anterior wing large, triangular, directed upward and slightly outward, the distal corner a right angle, the posterolateral margin curved. There is a sharp flexure in the distal part of the wing which may form a wing process on the inner side.

On the external surface of the exoskeleton (Pl. 55, figs. 7, 9; Pl. 57, fig. 9) are fine, raised, anastomosing lines that on the glabella in front of the occipital ring run roughly concentrically with the margins, on the cheeks run concentrically around the eye lobe, towards the margins becoming subparallel to these margins. On the doublure the lines are stronger; on the hypostome they run roughly parallel to the margins on the borders. The occipital ring does not bear a median tubercle, but medially four pits, arranged at the corners of a small square, are impressed in it. This arrangement of pits recalls those seen in odontopleurids (Whittington, 1956, pp. 177-178). In this species, as in odontopleurids, the doublure of the occipital ring extends close beneath this area.

The smallest well-preserved cranidia (Pl. 56, figs. 3, 4) are not greatly different from larger examples, except that the axial furrow is markedly deeper where it passes between the glabella and the lateral muscle area.

Pygidium (Pl. 57, figs. 1-8) has the axis extending about half the length (sag.), bluntly terminated, and on the external surface the characteristic postaxial ridge is faintly or not at all visible. Pleural regions gently curving down to margin, no border, broad facet and shallow first pleural furrow immediately behind the facet. On the external surface the terrace lines run subparallel to margins. Doublure is broad, convex ventrally, the outer part flattened, the inner part curving up to the margin, which runs immediately behind the tip of the axis and curves around to the inner end of the facet. Transitory pygidia (Pl. 57, figs. 10, 11) have the axis relatively longer, and display radially-arranged pleural ribs. Those of the smallest example bear a few low tubercles, and at the tip are extended as short spines. The first four segments show that these pleural ribs are the posterior bands.

On internal moulds of both cephalon (Pl. 58, figs. 1, 7) and pygidium (Pl. 57, fig. 13), between axial furrow and inner margin of doublure, there is a reticulate pattern of low ridges. Such a pattern, common in older trilobites (Öpik, 1961a) has not previously been observed in species of scutelluids, and most remarkable is the arrangement seen on the pleural regions of the pygidium. Immediately behind the first pleural furrow is a main ridge that runs directly out from axial furrow to the inner margin of the doublure. Opposite the second and third ring furrows of the axis similar ridges may be observed, running outward and backward. Between and behind these main ridges is a network of similar ridges. The main ridges appear to be related to segmentation, as Öpik (1961a, pp. 422, 426, pl. 69; text-figs. 10, 14) observed to be the case in certain Cambrian trilobites. The internal mould of the fixed cheek shows the relatively broad, flat-topped eye ridge, running inward to the axial furrow. This ridge is faintly, if at all, visible on the external surface of the exoskeleton, and is best seen in the small cranidium (Pl. 56, fig. 3). There is no sign on the external surface of the network of ridges, though the exoskeleton is thin.

Some variation is exhibited between specimens of the cephalon or cranidium of *R. recticulatus*. These are in outline and relative width of the glabella, and in convexity and relative height of the inner part of the cheek lobe (compare Pl. 56, figs. 8 and 10). Thus the eye lobe may be as high as the median part of the glabella or stand above it. Two examples of a cranidium (Pl. 58, figs. 2-4, 10; and one from Table Cove) are unusually convex. The anterior half of the glabella slopes steeply, as does the adjacent part of the fixed cheeks, these slopes being far more steep than in ''typical'' specimens, and the gently sloping border is much narrower. Other features of these cranidia appear to be the same — the muscle areas, arrangement of lines, and the four pits on the occipital ring. These cranidia may represent extreme variants, a rare, separate species, or least likely, the effect of distortion.

Discussion. The lectotype of *Raymondaspis angelini* (Billings, 1862, pp. 95-96, fig. 85a, b; this paper, Pl. 56, figs. 11-13) is from the ''upper part of limestone No. 2,'' that is from a boulder in a band of limestone conglomerate in the Lévis Shale. Billings (1862, p. 67) states that limestone No. 2 is included in No. 4 of Logan, but Logan (1863, p. 864) records this species from band No. 8. The age may be Lower or Middle Ordovician. The cephalon of *R. angelini* appears similar in outline, position of eye lobe, course of sutures and paradoublural line, to that of *R. reticulatus* n. sp., differing in the lower convexity of cheek and glabella, the relatively narrower and shorter glabella, in front of which is a much longer (sag. and exs.) preglabellar area. Raymond (1925, pp. 70-71) described, but did not figure, the species *R. marginata* from a boulder in the Mystic Conglomerate, Quebec. The holotype (MCZ 1759) is that part of the cranidium in front of the palpebral lobes. The glabella is broad (tr.) anteriorly, curving without interruption by a change in slope into the broad (sag. and exs.) preglabellar area. In these characters it appears to differ from both *R. angelini* and *R. reticulatus* n. sp.

As discussed above, *R. reticulatus* is like the younger *R. gregarius*, and the type material of the latter species shows the four pits on the occipital ring and the pattern of ridges on the internal mould of the pygidium. *R. brumleyi* (Cooper, 1953, p. 25, pl. 9, figs. 8-10) differs from both species in the rapid anterior expansion and convexity of the glabella, and the narrow preglabellar field. Comparison with *R. tennesseensis* (Cooper, 1953, p. 25, pl. 9, fig. 11) is less possible because of the indifferent preservation of the holotype.

RAYMONDASPIS TURGIDUS n. sp.

Plate 58, figures 5, 6, 8, 9; Plate 59, figures 1-9, 11

Holotype. GSC 18339, incomplete cranidium from middle Table Head Formation, type section, 190 feet above base.

Other material. Two cranidia, two free cheeks, and five pygidia from the same horizon and locality as the holotype.

Description. This rare species is quite different from *R. reticulatus* n. sp., and such similar species as *R. gregarius*, in that the glabella is much more convex both longitudinally and transversely, with more deeply impressed furrows and a basal lobe, a deep anterior pit and lateral muscle area; there is no anterolateral border to the cephalon, the genal angle is not prolonged into a blade-like spine, and the pygidium is relatively wider, with a bluntly terminated axis and the inner part of the pleural lobes inflated.

The outer part of the occipital furrow is broadened and deepened, and in front of it is the gently inflated, triangular, lateral glabellar lobe 1p. Lateral glabellar furrow 1p is markedly impressed, oval in outline, extending inward and backward along the inner side of the lateral lobe. Lateral glabellar furrows 2p and 3p (Pl. 59, fig. 7) are small circular areas, smooth but not impressed, situated a short distance in from the axial furrow, the terrace lines curving around them. Small, deep anterior pit near anterior end of axial furrow. Axial furrow beside lateral glabellar lobe 1p deeply and widely excavated, the excavation extending into the steeply sloping wall of the fixed cheek — this depressed region appears to be the lateral muscle area. Cheek triangular in outline, convex, eye lobe at highest point (as high as median part of glabella), this point situated about halfway out across the cheek and far back, in line with the lateral muscle area. Anterior branch of suture runs almost directly forward to border, and continues along outer edge of narrow anterior border. Posterior branch curves slightly, running outward and backward to cross the posterior margin close to the genal angle.

Visual surface (Pl. 59, figs. 2, 3) extends around anterior, lateral and posterior side of eye lobe, but not as in *R. reticulatus* around the inner side. Outside the eye lobe the cheek descends steeply to the narrow, rim-like border, which continues around in front of the glabella (Pl. 59, fig. 8), separated from it and the cheek by a shallow furrow. Only the posterolateral part of the cheek is slightly flattened, separated by a change in slope from the inner portion. External surface of cephalon bearing anastomosing raised lines, which run in curves convex forward on the occipital ring, concentrically on the remainder of the glabella, and concentrically around the eye lobe.

Pygidium more than twice as wide as long (sag.), relatively broad axis extending slightly more than half the length and bluntly terminated, no postaxial ridge. First four axial rings outlined by ring furrows which are deepest distally, and become successively shallower posteriorly. Pleural regions divided into an inner, gently inflated portion and an outer sloping portion which lies over the broad doublure (Pl. 59, fig. 11). Anterolaterally there is a broad diagonal facet. First pleural furrow shallow, curving out along inner side of facet, faint second pleural furrow. External surface bearing raised lines which run in curves convex forward on the axial rings, concentrically on the inner part of the pleural regions, and on the outer part subparallel to the margins. Doublure lies close to the dorsal exoskeleton, and is traversed by heavier terrace lines.

Small pygidium (Pl. 58, figs. 5, 6) has four axial rings clearly defined, and a faint fifth, and the axis is prolonged across the outer part of the pleural regions to the margin. On the inner part of the pleural region the first pleural furrow is broad and relatively deep, and a shallow second and third furrow is visible.

Discussion. No pattern of radiating ridges has been observed on internal moulds, but few specimens are available. The lack of this pattern, and the many other differences between *R. turgidus* and *R. reticulatus*, suggest that they might be accorded generic rather than specific rank. In view of the small amount of material of *R. turgidus* available, this is not done here.

Family CHEIRURIDAE Hawle and Corda, 1847

Subfamily CHEIRURINAE Hawle and Corda, 1847

Genus CERAURINELLA Cooper, 1953

CERAURINELLA POLYDORUS (Billings, 1865)

Plate 60

Billings, 1865, p. 286, fig. 274.
Barton, 1913, pp. 548-549.
Barton, 1916, p. 134.
Raymond, 1925, p. 143.
Whittington, 1963, pp. 85-86, pl. 25, fig. 10.

Lectotype. GSC 685, an incomplete cranidium (Whittington, 1963, pl. 25, fig. 10), previously designated holotype, but one of the syntypes studied by Billings. These latter also include GSC 685b, 685c, fragments of the glabella (GSC 685a is the posterior part of the glabella and cheek of *Pseudomera* sp.). All are from Portland Creek.

Other material. Both Billings and Raymond studied material from the upper half of the middle Table Head Formation. In the present investigation it was found rarely at 90 feet above the base of the middle part, and somewhat more abundantly in the isolated limestone and the exposures on the foreshore south of Table Cove.

Description. Glabella narrowest across occipital ring, which is broadest sagittally and projects behind the remainder of the cranidium. In front of this ring glabella expands gradually to the maximum width across lateral lobes 3p. Glabella moderately convex transversely, more strongly so longitudinally, and frontal lobe overhangs preglabellar furrow. Glabella subdivided by furrows which are deepest distally; occipital furrow curves forward slightly at midline; three pairs of lateral glabellar furrows subequally spaced from each other and from the occipital furrow and anterior margin. These furrows run transversely adjacent to the axial furrow, curving inward and backward proximally; lateral furrow 1p dying out without reaching the occipital furrow, but connected to the latter by the depression which separates the median glabellar lobe from the gently inflated basal lobe. Lateral lobes 2p and 3p progressively less strongly inflated, and not separated by a furrow or change in slope from the convex median lobe. Anterior glabellar lobe relatively short, the length (as measured between the anterior margin and the outer ends of lateral furrows 3p) only slightly greater than the length (exs.) of lateral lobes 2p and 3p, but less than that of 1p. Axial and preglabellar furrows of similar depth, at their junction a deep anterior pit. Narrow, gently convex anterior border outside preglabellar furrow, margin defined by sutures, and the oblique angle in this margin (Pl. 60, fig. 1) probably marks the junction between rostral suture and anterior branch. Fixed cheek (Pl. 60, figs. 1, 4, 6) curves gently downward and outward from axial furrow. Posterior border convex, widening outward to a maximum width at the genal angle, where it merges with the equally broad anterolateral border. At the genal angle the specimen is broken, but the genal spine is evidently broad-based, directed backward and outward. Palpebral lobe situated at about one-third the width (tr.) out across the cheek and opposite lateral glabellar lobe 2p. The steeply inclined lobe is continuous with a broad eye ridge which runs inward and forward to reach the axial furrow opposite lateral glabellar lobe 3p. This eye ridge is well defined on the inner side by a furrow which continues along the inner margin of the palpebral lobe. In front of the eye ridge is a narrow part of the fixed cheek, which is separated by the deep outward and slightly forwardly directed border furrow from the anterior border. Anterior branch of facial suture bounds this portion distally, and curves inward and forward across the outer slope of the anterior border. Posterior branch of suture evidently runs outward and slightly forward to lateral border furrow, then curves outward and backward across the lateral border (Pl. 60, fig. 6). External surface of glabella and borders finely granulate, except in furrows. In no specimen is the external surface of the exoskeleton well preserved, and in that figured (Pl. 60, fig. 11) the exoskeleton is partly exfoliated. Fixed cheek inside border furrows impressed by deep, closely spaced pits.

Pygidium triangular in outline, the short axis composed of three convex rings separated from each other by deep ring furrows. At anterior margin pleural region of similar width (tr.) to axial ring, first pleura separated from ring by shallow axial furrow and adjacent to this furrow the short, shallow pleural furrow. Second and third pleural bands gently convex, separated from each other and the first pleural band by deep interpleural furrows. The first pleura extended by a large, thick, upward, outward and backwardly directed pleural spine, the spine of the second and third pleurae much smaller, triangular in shape, those of the third pleurae separated by a narrow posterior part of the pleural region. Beneath the bases of these spines the pleural region descends vertically to the margin, where it is curled under to form the doublure. In posterior aspect (Pl. 60, fig. 10) this vertical border region is seen to be excavated by a broad, median notch. External surface finely granulate except in furrows.

Discussion. This species is quite like the type species of *Ceraurinella, C. typa* Cooper, 1953 (pp. 29-30, pl. 12, figs. 1-5, 7, 8, 15, 16; Whittington and Evitt, 1954, pp. 62-66, pls. 10-12, pl. 13, figs. 1, 3; text-figs. 2, 3, 4, 17), the cranidium differing in that the glabella is markedly tapered at the occipital ring, the frontal glabellar lobe is much shorter (sag.) and narrower (tr.), and the external surface is finely granulated and not coarsely tuberculate. The pygidium, like that of *C. typa,* possesses three pairs of pleural spines, the first much thicker and longer than the second and third; however in *C. polydorus* these three pairs of spines are more widely divergent, and the inner pair is separated by a narrow posterior portion of the pleural region. Tripp (1962, pp. 16-19, pl. 2, figs. 22-32) emphasizes that the distinguishing feature of his genus *Bartoninus* is the graduated size of the pleural spines of the pygidium, so that *C. polydorus* is probably better placed in *Ceraurinella* than in *Bartoninus.* The Table Head species differs from *Lehua argus* Whittington, 1963 (pp. 84-86, pl. 23, figs. 1-4, 6, 8, 9, 11; ? 5, 7) in that the frontal glabellar lobe of *L. argus* is relatively shorter and narrower, so that furrow 3p runs inward from the anterolateral corner, and the eye lobe is situated at the anterolateral margin of the cheek. If the pygidium described is correctly assigned to this species, it is quite different from that of *C. polydorus.* Prantl and Přibyl (1948, pp. 21-23, pl. 1, figs. 8, 9; pl. 5, fig. 8) erected the genus *Osekaspis* with the type species *Cheirurus comes* Barrande, 1872, from the Šárka Beds of Llanvirn (early Middle Ordovician) age, Bohemia. Only the cephalon of the type species is known, and while it is of general ceraurid type, it differs from that of *C. polydorus* in displaying a much broader, flattened, horizontally directed anterior border, in the course of the posterior branch of the suture, and the apparently smaller fixigenal spine. Most like the Table Head species is that described by Schmidt (1881, pp. 135-136, pl. 6, figs. 1, 2) from the Lower Ordovician of the East Baltic, and also recorded from Sweden (Bohlin, 1949, p. 566) in rocks of similar age. The outline and lobation of the glabella is similar, as is the position of the eye lobe, course of the sutures, and particularly the broad-based, outwardly and backwardly directed fixigenal spine.

C. polydorus is the earliest representative of this genus in North America.

Subfamily SPHAEREXOCHINAE Öpik, 1937

Diagnosis. Axis of exoskeleton relatively wide, so that glabella dominates cephalon; three pairs of glabellar furrows, 1p deeper and longer than furrows 2p and 3p. Eye lobe situated close to axial furrow, free cheek triangular in outline. Rostral plate relatively wide (tr.) and short (sags. and exs.). Hypostome with small anterior wing, middle body gently inflated and subequally divided by short middle furrows, lateral borders of similar width to posterior borders, a shallow median notch in the posterior border. Doublure of thorax and pygidium extends in to axial furrow, pleurae may be tubular spines in thorax and similar free spines in pygidium, or may be flattened and facetted in the thorax and completely or partially fused in the pleural regions of the pygidium. External surface granulate and bearing scattered tubercles, cheek may be pitted inside border furrow.

Discussion. In a previous discussion (Whittington, 1963, pp. 89-90) of this subfamily it was enlarged to include the genera *Kawina* and *Cydonocephalus*. It is here suggested that *Xystocrania* n. gen., which appears to be related to *Kawina,* be placed here, and in addition *Heliomera*. The latter genus was thought by Evitt (1951, p. 588) to occupy an isolated position among cheirurids in a separate subfamily, but his list of characteristics is like many of those given above, except for the radial arrangement of the glabellar furrows which is characteristic of the *Heliomera* group of species.

Sphaerexochinids as understood here include a group of trilobites particularly characteristic of Middle Ordovician rocks in North America, only *Sphaerexochus* being more widely known at this time and ranging into Silurian rocks. A possible older, Lower Ordovician, representative of this group may be *"Kawina" sexapugia* Ross, 1951 (pp. 126-129, pl. 35, figs. 6, 7, 11-17, 19-21), and another member may be Ross' undetermined genus and species E (1951, pl. 35, figs. 3-5), the cranidium of which has an appearance reminiscent of *Heliomera*, though the glabellar furrows do not show the characteristic radial arrangement, nor is the glabella so markedly transversely oval in outline.

Genus XYSTOCRANIA n. gen.

Type species. Cheirurus perforator Billings, 1865.

Diagnosis. Differs from *Kawina* (see Whittington, 1963, pp. 90-91) in that lateral glabellar furrow 1p is less markedly S-shaped, furrows 2p and 3p may be faintly impressed, there is no hump on the glabella in front of the occipital furrow, but a long spine, directed upward and forward, situated on the anterior part of the median glabellar lobe. Fixigenal spine present, posterior branch of suture crosses border a short distance outside this spine. The pygidium attributed to *Xystocrania* (Hintze, 1953, pl. 28, figs. 4a, 4b, 5) differs from that attributed to *Kawina* in that the terminal portion of the axis, behind the third ring, is absent, and the three pairs of pleural spines diverge and are not fused, but separated from each other near the base. Differs from *Nieszkowskia* Schmidt, 1881, in the position of the glabellar spine, which is situated on the posterior part of the median glabellar lobe in *Nieszkowskia*, in the S-shape of lateral furrow 1p, in that lateral furrows 1p to 3p commence at the axial furrow in *Nieszkowskia,* and the pleural regions of the pygidium are composed of two pairs of spines, the first of which is long, the second much reduced.

Discussion. Included in this genus is the species from Quebec described below, and *X. unicornica* (Hintze, 1953, pp. 179-181, pl. 28, figs. 1-5) from zone N, upper Pogonip Group, Crystal Peak, Utah. A slightly different and undescribed species occurs in beds of the same age in Ike's Canyon, Toquima Range, Nevada. Only in the last-mentioned two species is the pygidium known.

From lower Ordovician rocks of Utah comes "*Kawina*" *sexapugia* (Ross, 1951, pp. 127-129, pl. 35, figs. 6, 7, 11-17, 19-21). The cephalon of this species is unlike that of *Kawina* in the form of the glabella, which lacks the posterior hump, and in the position of the eye lobe and course of the posterior branch of the suture; in these respects it is more like that of *Cydonocephalus*. The pygidium is like that of *Xystocrania,* consisting of three segments, the pleural spines being separate from each other and divergent. This species may represent a separate genus which is older than species of the genera mentioned above.

XYSTOCRANIA PERFORATOR (Billings, 1865)
Plate 61

Billings, 1865, p. 287, fig. 275.
Raymond, 1925, pp. 146-147.
Nieszkowskia excelsus Raymond, 1925, pp. 145-146, pl. 10, fig. 8.

Holotype. GSC 684, incomplete cranidium, original of Billings, 1865, figure 275, from ''Division N, Table Head.'' This label implies that the specimen came from the upper part of the middle Table Head Formation at the type section and the matrix is a black, fine-grained limestone typical of this part of the formation.

Other material. YPM 23332, glabella lacking occipital ring, showing furrows 1p and base of spine, from Pointe Riche, original of Raymond, 1925, pages 146-147; YPM 13046, external mould of left half of cephalon, holotype of Raymond's *N. excelsus*, from lower Table Head Formation, Port au Choix. In the present investigation an incomplete cranidium was obtained from 379 feet above the base of bed 8, type section of lower Table Head Formation, and a hypostome from 350 feet above the base of the same bed.

Description. Maximum width of strongly convex glabella immediately behind outer end of lateral furrows 1p, at slightly more than half the length from the anterior margin. Occipital furrow straight medially, narrow and deep, occipital ring not markedly wider medially. Glabella bulges forward anteriorly and overhangs narrow anterior cephalic border, thick, forwardly and upwardly directed spine arises from anterior part of median lobe. Lateral furrow 1p commences a short distance inside axial furrow, is weakly sigmoidal, the inner ends of the two furrows close together but not extending to the occipital furrow. Lateral furrows 2p and 3p (Pl. 61, figs. 5, 8) are faint, curved, commence a short distance inside the axial furrow, 2p curving up toward the base of the median spine, 3p lying in front of the base of this spine. Narrow, deep, axial furrow forms a continuous curve with pregabellar furrow which is of similar depth. Cheek triangular in outline, curving outward and downward, borders defined by deep furrows and widest posterolaterally. The posterior border widens progressively outward to the base of the backwardly and outwardly directed fixigenal spine, outside the base of this spine (Pl. 61, fig. 8) the border curves gently forward to merge with the lateral border. Eye lobe medially situated, opposite outer end of lateral furrow 1p, prominent, defined on inner side by deep, curved palpebral furrow. Anterior branch of suture runs inward and forward to cross anterior border in line with axial furrow, further course not clearly visible. Posterior branch curves outward and backward through about 90°, crossing the border a short distance outside the base of the fixigenal spine. The hypostome assigned to this species is subquadrangular in outline, the lateral and posterior borders of similar and constant width, separated from the middle body by broad deep furrows. Middle body gently convex, at about midway along lateral margin the middle furrow curves for a short distance inward and backward.

External surface except in furrows finely granulate. On glabella scattered tubercles, which are larger on the posterior portion behind the median spine, smaller in front of it. Cheek inside border furrows impressed by irregular, closely-spaced pits.

Discussion. This species is extremely rare, and only the cephalon is known, yet it is one of the few that ranges from the lower into the middle Table Head Formation. Raymond distinguished his species *excelsus* because of the supposed direction of the median glabellar spine. This is a matter of orientation, however, and Raymond's specimen is closely similar to the type both in size and appearance. *X. unicornica* (Hintze, 1953, pl. 28, figs. 1-5) is extremely like the present species, but distinguished by the less convex and forwardly projecting glabella, as evidenced by comparisons of the dorsal and lateral profiles. The hypostomes of the two species are similar in type, but that of *X. unicornica* is semicircular rather than subquadrangular in outline.

XYSTOCRANIA GLAUCUS (Billings, 1865)

Plate 62, figures 4, 8, 9

Billings, 1865, p. 323, fig. 308, a, b.

Lectotype. GSC 850, internal mould of incomplete cranidium, from boulder in Mystic Conglomerate, Range 6, Lot 20, Stanbridge Township, Missisquoi County, Quebec.

Paralectotype. GSC 850a, distorted incomplete internal mould of part of glabella and left fixed cheek. Same locality as lectotype.

Description. Glabella widest at about midlength of lateral lobes 1p, in front of here tapering quite rapidly, highest point at base of median spine, which is approximately in line with lateral glabellar furrows 2p; in front of spine, glabella slopes steeply forward and only slightly overhangs preglabellar furrow. Lateral glabellar furrows commence a short distance inside axial furrow, deepest and widest distally, narrowing and shallowing inward; furrow 1p the deepest and longest, the inner ends not reaching the occipital furrow and relatively far apart. Lateral furrows 2p and 3p successively shallower and shorter. Occipital furrow transverse, occipital ring of maximum width medially. Posterior border of fixed cheek narrow and convex adjacent to axial furrow, widening (exs.) rapidly outward. Fixed cheek curves steeply downward, palpebral lobe situated in line with lateral furrow 2p. External surface of exoskeleton not preserved, but pitting of cheek shows in internal mould.

Discussion. This cranidium differs from that of *X. perforator* in the outline and convexity of the glabella (compare Pl. 61, figs. 1-8 with Pl. 62, figs. 4, 8, 9), particularly as revealed in comparisons of the profiles. Lateral furrows 2p and 3p are deeper, the palpebral lobe is situated farther forward, being opposite lateral furrow 2p rather than 1p, and the median glabellar spine is differently placed in association with the different longitudinal convexity of the glabella.

From the lower Table Head Formation a single incomplete cranidium was collected (Pl. 62, figs. 1-3, 6) which is like that of *X. glaucus.* This specimen is not exfoliated, the occipital ring is complete, and close to the posterior edge is the base of a thick median spine. It appears probable that such a spine is not present in *X. glaucus,* but since the occipital ring is incomplete in the only two specimens known, one cannot be sure. On the external surface of the glabella and posterior border of the Table Head specimen is a fine granulation, amid which are scattered low tubercles apparently not arranged in pairs. The fixed cheek inside the border is pitted, and a few low granules are scattered on the ridges between the pits. The posterior border is preserved, showing the distal widening which is extended outward and backward by the long, stout fixigenal spine.

Genus CYDONOCEPHALUS Whittington, 1963

CYDONOCEPHALUS sp. ind.

Plate 63, figures 9, 10, 13, 16

Material. GSC 18356, incomplete cranidium, middle Table Head Formation, foreshore south of Table Cove.

Description. Cranidium is typical of the genus (compare Plate 63, figures 9, 10, 13, 16 with Whittington, 1963, pl. 28, figs. 1-15) in the outline of the glabella in dorsal and lateral profile, the deep lateral glabellar furrow 1p and faint furrows 2p and 3p, position of the palpebral lobe, and form of the posterior border with the thorn-like fixigenal spine. Of the species previously described, it resembles *C. scrobiculus* in the shape of the posterior part of the fixed cheek and particularly the broad, deep border furrow. However, the glabella of the present species has less deep and more backwardly directed lateral glabellar furrows 1p, so that the basal glabellar lobe is more triangular than quadrangular in outline, and furrows 2p and 3p are much fainter.

Genus KAWINA Barton, 1916

KAWINA sp. ind.

Plate 62, figures 5, 7

Material. GSC 18274, an incomplete pygidium in the same piece of rock as the original of Plate 47, figures 3, 5, 6, and partly concealed by this cranidium, lower Table Head Formation, Pointe Riche.

Description. This pygidium is typical of the kind assigned to this genus, and of the species recently described is most like that of *K. arnoldi* Whittington, 1963 (p. 94, pl. 26, figs. 12, 14; Pl. 27, figs. 2, 5, 6, 8 9). As in this species the terminal portion of the axis is relatively large and triangular in outline, but the axis is of width (tr.) across the first ring greater than the length (sag.), and the third ring furrow has a bow-shaped course rather than being curved convexly back as in *K. arnoldi.* The external surface of the present example is finely granulate (except in the furrows), and there are scattered low tubercles, which are smooth and may display a tiny opening on the posterior-facing slope.

Genus HELIOMERA Raymond, 1905

Type species. Cheirurus sol Billings, 1865.

Discussion. In 1951, Evitt redescribed the type species and distinguished from it three other species grouped in a new genus *Heliomeroides.* From the boulder at Lower Head came two species (Whittington, 1963, pp. 86-89, pl. 24; pl. 25, figs.

1-6), one being placed in each of these genera. All but the type species of *Heliomeroides*, *H. teres*, are known only from the glabella, cranidium, or at most, cephalon. Assignment to *Heliomera* or *Heliomeroides* depends entirely therefore on characters of the cephalon, particularly the glabella, and in practice on the development and depth of the longitudinal furrow that joins the inner ends of the lateral glabellar furrows to each other and to the occipital furrow. When the material available is in the form of internal moulds, as for example in *H. raymondi* (Evitt, 1951, pl. 85, figs. 6-14) the longitudinal furrow appears deep and broad, and the assignment to *Heliomeroides* may be made on the basis of this single character, although the appearance of the furrow on the external surface is unknown. In *Heliomera* there is a change in slope along the line of this furrow, but a furrow is not developed, while in *Heliomeroides alacer* Whittington, 1963 (pl. 25, figs. 1, 2, 4-6), the longitudinal furrow is broad and shallow, lying between the gently convex median glabellar lobe and the inflated lateral lobes. The variability in development of the furrow emphasizes the difficulty of using this one character in classification, and it is here suggested that the name *Heliomeroides* be used for a subgeneric group of species of *Heliomera*, pending a more complete knowledge of exoskeletons which may enable the use of more than one character to distinguish them.

HELIOMERA SOL (Billings, 1865)

Plate 63, figures 1-6, 8, 12

Billings, 1865, p. 288, fig. 276.
Evitt, 1951, pp. 603-605, pl. 85, figs. 24-29.
Whittington, 1963, p. 88.

Lectotype (selected by Evitt, 1951). GSC 683, incomplete cranidium from middle Table Head Formation, probably type section. Since Evitt described this specimen (from a cast), I have been permitted to prepare it, and the left side of the glabella and left fixed cheek are now visible. It is in a fragment of light gray, medium-grained lime sand with specimens of *Niobe quadraticaudatus*, and there is little doubt that age and locality are as given.

Other material. GSC 18354, a less complete cranidium from the isolated limestone.

Description. Glabella transversely oval in outline, gently convex, distal parts of lobes inflated so that close to axial and preglabellar furrows the slope is steep. Occipital and three lateral furrows divide the glabella so that the median lobe is approximately two-thirds the width (tr.) of the lateral lobes, and in the lateral region the furrows are subradially arranged. Occipital furrow deep and transverse behind median lobe, curving outward and backward and deepening behind lateral lobe. Posterior margin of occipital ring curves convexly back so that width (sag.) is greatest behind median lobe. Lateral glabellar furrows 1p and 2p of similar depth and length, slightly curved, furrow 3p straight and running inward from the preglabellar furrow. Median lobe expands abruptly into short (sag. and exs.) frontal lobe, which latter is indented by a shallow notch in the anterior margin at the midline. Axial and preglabellar furrows narrow and moderately deep, narrow anterior border. Fixed cheek slopes steeply outward, anterior portion extremely narrow (tr.), posterior portion of width at posterior border similar to width (tr.) of basal lateral glabellar lobe. Posterior border furrow narrow and deep, curving outward and forward, more strongly forward distally as it approaches sutural margin. Posterior border thus widens (exs.) outward; at genal angle it is extended by a slim, backwardly and outward directed spine; in front of base of spine a narrow border extends to the sutural margin. Palpebral lobe situated opposite anterior part of second lateral glabellar lobe, shallow palpebral furrow, posterior branch of suture curves outward and backward.

External surface except in furrows covered by scattered tubercles of varying size, irregularly arranged. Cheek inside border furrows impressed by pits.

Discussion. Distinctions between *H. sol* and the Lower Head species *H. albata* have been given (Whittington, 1963, p. 88), and now that *H. sol* is better known it is clear that the convexity of the glabella of *H. albata* distinguishes it, combined with the unusual "L" shape of lateral glabellar lobe 3p. It is also notable how like *H. sol* is *H.* (*Heliomeroides*) *alacer* Whittington, 1963 (compare Plate 63, figure 5, with pl. 25, fig. 6), the latter species being distinguished by the more inflated lateral glabellar lobes, the anterior median line of pits in the frontal lobe, the more anterior position of the eye lobe, and the stouter and differently directed fixigenal spine.

HELIOMERA (HELIOMEROIDES) sp. ind.

Plate 63, figures 7, 11, 14, 15

Heliomera sol, Whittington and Kindle, 1963, fig. 3.

Material. GSC 18355, internal mould of glabella, middle Table Head Formation, 17 feet above base of type section.

Description. The glabella is distinguished from that of *H. sol* by the depth of the furrows and the inflation of the lateral lobes, which gives a much more marked subdivision of the glabella, accentuated by its being preserved as an internal mould. Laterally the slope to the axial furrow is vertical, the longitudinal furrow is marked, and there is a short, shallow median furrow running inward from the anterior margin of the frontal lobe. This fragment is of the *Heliomeroides* type, and like *H.* (*H.*) *alacer* Whittington, 1963.

Family CALYMENIDAE Edwards, 1840

Genus CALYMENIDIUS Rasetti, 1944

aff. CALYMENIDIUS sp. ind.

Plate 59, figures 10, 12-15

Material. Two cranidia from middle Table Head Formation, Table Cove.

Description. Cranidium is incomplete but shows the subtrapezoidal outline of tapering glabella, which does not reach as far forward as the inflated fixed cheeks. Occipital ring narrow distally, curving forward; occipital furrow deep in front of this narrow outer part of the ring. Lateral glabellar furrow 1p runs diagonally inward from a point behind the midlength of the glabella, isolating a small, triangular basal lobe. Lateral furrow 2p a small depression in the side of the glabella close to the axial furrow at about one-third the length. Fixed cheek strongly convex, standing almost as high as the glabella, separated from it by the deep axial furrow. Opposite lateral glabellar lobe 1p is a shallow crescentic excavation in the steep wall of the cheek, the ala; opposite the anterolateral corner of the glabella is the shallow anterior pit. Palpebral lobe situated far out on the cheek and opposite the midlength of the glabella. Anterior branches of suture appear to converge forward, posterior branches not preserved. In anterior view (Pl. 59, fig. 14) the strongly convex anterior border is seen to be arched transversely through almost 180°, separated from the glabella by a deep preglabellar furrow, and a similarly deep furrow from the cheek. The exoskeleton is preserved only in the anterior part of the right fixed cheek, and exhibits tubercles of varying size, closely spaced, on the external surface. On the internal mould a low eye ridge is seen to run inward and forward across the cheek to reach the axial furrow immediately behind the anterior pit.

The smaller cranidium (Pl. 59, figs. 10, 12, 13) appears to belong to the same species, though the subparallel-sided glabella is relatively longer, extending as far forward as the fixed cheeks. The glabella shows the same two pairs of lateral furrows, the anterior border of the cranidium is similarly arched transversely, and the position of the eye lobe is similar. External surface of exoskeleton is tuberculate.

Discussion. This cranidium is like that of *Calymenidius tuberculatus* Rasetti, 1944 (pp. 240-241, pl. 36, fig. 54), from a presumed late Cambrian boulder in the Lévis Conglomerate. Only the holotype of the type species is known, the glabella trapezoidal in outline, the fixed cheeks convex, and the anterior border arched. The Table Head specimen has a shorter and shallower lateral glabellar furrow 2p, and a less prominent eye ridge. Rasetti does not mention the presence of the ala. Possibly congeneric with *Calymenidius* is *Pharostomina* Sdzuy, 1955 (pp. 30-34, pl. 2, figs. 80, 99, pl. 6, figs. 62-88, text-figs. 31-33), in which the ala is a characteristic structure. *Pharostomina* is known not only from the Tremadoc of Germany, but also from beds of similar age in Argentina (Harrington and Leanza, 1957, pp. 222-224, figs. 123, 1-6; these authors erected the genus *Colpocoryphoides*, which appears to be a synonym of *Pharostomina*). The Table Head cranidia are less like that of *Pharostoma* (Whittington, *in* Moore, 1959, p. O454, fig. 357) which has a relatively wider glabella, less convex fixed cheeks, and a wider, less arched preglabellar area.

Family ENCRINURIDAE Angelin, 1854

Diagnosis. Moderately or strongly convex glabella may expand forward, be parallel-sided or widest at the midlength. Occipital ring well-defined, widest (sag.) medially; up to three pairs of lateral glabellar furrows may be present; these furrows may deepen inwards to form apodemes, or may be absent distally so that the lateral lobes are fused. Lateral furrow 3p may be forked, lateral lobe 3p may be the longest (exs.). Deep anterior pit at, or in front of, junction of preglabellar and axial furrows. May be median pit in preglabellar furrow, median furrow or pit at anterior end of frontal lobe. No preglabellar field, anterior border present but preglabellar furrow may be effaced medially. Eye lobe frequently elevated on stalk, strong eye ridge. Rostral plate steno-ptychopariid in type. Posterior branch of suture cuts lateral margin in front of genal angle, fixigenal spine may or may not be present. Hypostome with convex middle body ovate in outline, median bulge at anterior margin typical, no anterior border, narrow lateral borders, wide (sag. and exs.) posterior border; anterior wing with well-developed wing process.

Thorax of ten to twelve segments, posterior pleural bands wider and higher than anterior bands; former may be extended as spines; long spines on last six segments of thorax present in some genera. Pleural regions of pygidium composed of at least four segments, axis showing more rings than there are segments in the pleural regions; behind first few rings there may be a smooth median band on axis. External surface granulate, scattered tubercles or spines, frequently paired arrangement. Cheek inside border pitted.

Discussion. This diagnosis is similar to that recently given of the Pliomeridae (Whittington, 1961, pp. 912-914). The close relationship between Encrinuridae and Pliomeridae has frequently been commented on (e.g. Temple, 1956; Kielan, 1957, p. 157), and distinctive of the Encrinuridae is the nature of the pygidium, the axis showing many more segments than are present in the pleural regions, and the frequent presence of the smooth median band on the posterior part of the axis. In most Pliomeridae the number of rings on the axis does not greatly exceed the number of pleurae in the pleural regions, except in *Ectenonotus* (Whittington, 1961, pl. 99, figs. 2, 3, 6). This genus has a typically pliomerid cephalon, and reveals the closeness of the relationship between the two families. *Pseudocybele* Ross, 1951, has a cephalon more typical of encrinurids but a pliomerid pygidium. In addition to the distinctive pygidium, Encrinuridae have 10 to 12 segments in the thorax, not 12 to 18 as in Pliomeridae. The encrinurid hypostome, exemplified by those of *Encrinurus* (Lindström, 1901, pl. 4, fig. 5; Whittard, 1938, pp. 119-120, pl. 4, fig. 7) and *Cybeloides* (Cooper, 1953, pl. 13, fig. 12), appears different from those of typical pliomerids (Whittington, 1961, text-figs. 1-3, 5) particularly in showing the median anterior bulge on the middle body.

Encrinurids appear in the early Ordovician — *Cybele* in the Lower Ordovician of Scandinavia and the Baltic — and range through the Ordovician to the end of the Silurian. They originate at about the same time as pliomerids, and are well diversified by early Middle Ordovician times (Llanvirn or Whiterock Stages) being represented by *Cybellela* (Whittington, 1965), *Miracybele* n. gen., *Cornovica* Whittard, 1960 (a blind form from Britain), and *Plasiaspis* Prantl and Přibyl, 1948 (Whittard, 1960, p. 122), a related blind form from Bohemia. Additional genera appear in immediately succeeding stages (Llandeilo or Marmor-Ashby), such as another blind form *Dindymene, Cybeloides, Encrinuroides, Atractopyge,* and forms doubtfully referred to this latter genus.

Henningsmoen (*in* Moore, 1959, pp. O445-449) used four subfamilial divisions of Encrinuridae, and now that Staurocephalidae have been shown to represent a separate family (Kielan, 1957), three divisions remain. In the present uncertainty as to the nature of particular genera, and details of parts of the exoskeleton and particularly the hypostome, these subgroupings are not used here.

Genus MIRACYBELE n. gen.

Type species. Encrinurus mirus Billings, 1865.

Diagnosis. Glabella expands evenly forward to maximum width across frontal lobe, three pairs of lateral furrows transversely directed, deepest at inner ends, extending inward more than one-third the width so that median lobe is narrow (tr.); from outer end of furrow 3p a short, inwardly and forwardly directed branch runs on to frontal lobe. Shallow preglabellar furrow separates frontal lobe from steeply sloping anterior border, deep, transversely elongate median pit in furrow, from which a deep, median longitudinal furrow runs back to bisect frontal glabellar lobe. Eye lobe situated more than half way out across cheek, opposite lateral glabellar furrow 1p, prominent eye ridge runs in to axial furrow opposite outer end of lateral furrow 3p. Rostral plate of maximum width at anterior margin, this width about equal to that of median glabellar lobe, narrowing backward. Thorax of at least twelve segments, posterior pleural band strongly convex, that of sixth segment from rear prolonged by long spine. Pygidium having about 14 rings on axis, median smooth band present from fifth ring back; pleural

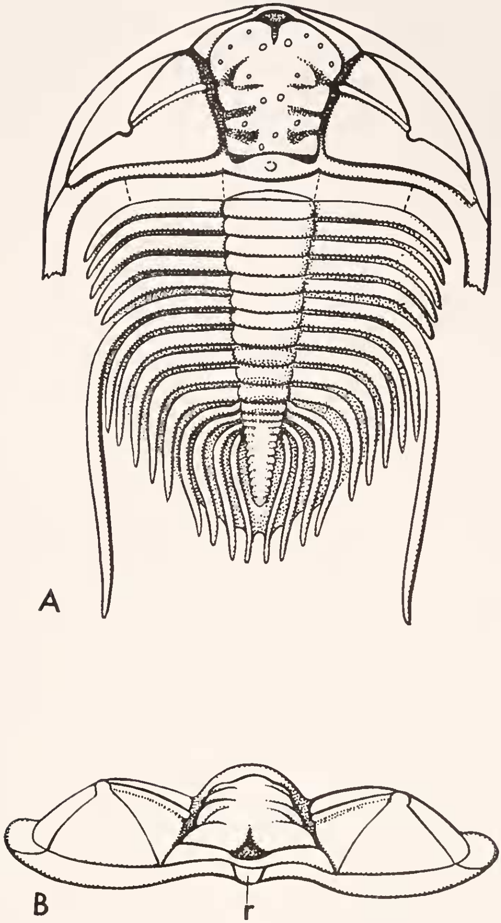

FIG. 7. *Miracybele mira* (Billings), middle Table Head Formation. A, reconstruction, dorsal view, showing eleven thoracic segments; complete thorax may have included twelve; B, anterior view of cephalon; r is rostral plate; X 3. Compare Plate 64, figures 1-7; Plate 65, figures 1-4; Plate 66, figure 4.

regions composed of four segments, posterior pleural bands prolonged as short spines.

Discussion. The deep pit in the preglabellar furrow, and the strong furrow running back from this pit on to the frontal glabellar lobe, combined with the relatively narrow median glabellar lobe, distinguish this genus from *Cybele* (type species *C. bellatula,* Schmidt, 1881, pp. 203-206, pl. 13, figs. 9-13; pl. 15, figs. 1-5), species of *Cybellela* and "*Atractopyge*" (for discussion of these genera and allied forms see Whittington, 1965). It is known from the type species in the middle Table Head Formation, and a second species appears to be present in the *Ogygiocaris* Shale of Norway (Nikolaisen, 1961, p. 295, pl. 2, fig. 4).

MIRACYBELE MIRA (Billings, 1865)

Plates 64, 65, 66, figures 1-4;
? 5-8; Text-figure 7

Billings, 1865, pp. 292-293, fig. 282.
Raymond, 1925, p. 135 (in part).
Howell, 1947, pp. 12-13, pl. 1, figs. 1-4.

Lectotype (here selected). GSC 697, incomplete exfoliated cranidium from middle Table Head Formation, Pistolet Bay.

Other material. Paralectotypes: from same locality and horizon as lectotype, GSC 697b, c, exfoliated and incomplete cranidia, GSC 697a, exfoliated pygidium, from middle Table Head Formation at type section, GSC 698, a-c, all pygidia. YPM 23327, 23328, poorly preserved cranidia from type section of middle Table Head Formation, the former the original of Howell, 1947, plate 1, figure 3, and showing fixigenal spines. In the present investigation this species has been obtained at 90 and 185 feet above the base of the middle Table Head Formation at the type section, and is relatively abundant at Table Cove and in the isolated limestone.

Description. Glabella moderately convex (sag. and tr.), expanding evenly forward from occipital ring so that width across frontal lobe is half again that across occipital ring. Latter widest (sag.) medially, because of convexly backward curvature of posterior margin and forward swing of midpart of occipital furrow; this furrow shallow behind median lobe, deepened to form an appendifer distally. Lateral glabellar furrows 1p and 2p are placed at a similar distance from each other, and the occipital furrow 3p at a somewhat greater distance from 2p. Lateral furrows extend inward to more than one-third the width, so that the median glabellar lobe is relatively narrow; 1p at the inner end deepened and widened to form an apodeme; 2p also deepened at inner end but not markedly widened; 3p runs slightly backward and inward and is deepest at the inner end, with a conspicuous branch commencing close to the outer end and running up the slope of the frontal lobe and dying out. Lateral glabellar lobes only slightly inflated, 3p the most strongly so. Deep anterior pit in axial furrow immediately in front of outer end of lateral glabellar furrow 3p. Anterior margin of frontal lobe rounded and outlined by preglabellar furrow which is shallow except for the short, straight, greatly deepened median portion. From this deep portion an equally deep median longitudinal furrow runs back on to the frontal lobe, rapidly shallowing and dying out at about half the length of this lobe. In front of anterior pit axial furrow runs outward beside that part of the anterior border which is on the cranidium; border is gently convex, widest (exs.) adjacent to the axial furrow and narrow medially. Cheek strongly convex, highest point situated inside eye lobe and at same level as mid-line of glabella, outer part of cheek slopes very steeply. Deep border furrows define the borders, the posterior border narrow and convex, running transversely outward from the occipital ring and curving back outside the eye lobe; lateral and anterolateral borders moderately wide, gently convex, borders broad at genal angle and extended back by fixigenal spine. This spine is rarely preserved, but some specimens (Pl. 64, figs. 6, 8, 9) suggest that it was short and blunt. Eye lobe apparently stalked but not well preserved, eye ridge prominent. Anterior branch of facial suture (Pl. 64, figs. 2, 6, 9) runs straight inward and forward to cross border furrow at junction with axial furrow, then curves to run inward and forward along the outer margin of the anterior cephalic border; in front of the deep, median part of the preglabellar furrow the sutural margin of the border is straight, this straight portion being the rostral suture. Doublure of border (Pl. 64, figs. 4, 5) wide anteriorly, connective suture runs inward and backward over this doublure, outlining a rostral plate which is narrowest (tr.) posteriorly (Text-fig. 7). External surface covered by dense, fine granulation except in furrows (Pl. 64, fig. 11; Pl. 66, fig. 1). Cheek inside border furrows impressed by pits; granulation extends on ridges between pits. Scattered amid the granules are tubercles of various sizes, including a prominent median occipital tubercle and roughly paired tubercles on the median glabellar lobe opposite lateral lobes 3p, and on the frontal lobe.

One poorly preserved specimen (Pl. 66, fig. 4) shows twelve thoracic segments and the pygidium articulated together. The convex axis tapers gradually, the inner part of the pleural regions tapers rapidly in width. Posterior pleural bands are strongly convex, and that of the sixth segment from the posterior is extended as a long, backwardly directed spine. Outer parts of pleural regions of other segments appear to end in short spines, and to be facetted.

Pygidium (Pl. 65) triangular in outline, moderately convex axis, inner part of pleural region horizontal, outer part bent down vertically. Axis tapers and extends close to posterior margin, divided by ring furrows, which are deep distally, into fourteen rings. On the external surface shallow ring furrows define the median part of the first four or five rings; behind this point the median part of the ring is faintly or not at all defined, giving rise to the smooth median band. This smooth median band is less conspicuous on the internal mould, but made evident by shallow median part of the ring furrows. Pleural regions composed of four segments, each divided by deep pleural furrows into a narrow, gently convex anterior band and a broader and more strongly convex posterior band; these posterior bands extended beyond the margins (Pl. 65, fig. 4) as short, inwardly and backwardly directed spines, the fourth pair close together at the posterior margin. External surface (Pl. 65, fig. 6) covered except in furrows by fine granulation, some low tubercles scattered on posterior pleural bands. Pleural and interpleural furrows of second, third, and fourth segments are impressed by irregular pits, these pits being especially large in the region between the tip of the axis and the fourth pair of posterior pleural bands. These pits have only been observed in this specimen which has the exoskeleton preserved; other specimens are all internal moulds and the exoskeleton is thick so that the pits are faintly or not at all impressed on the internal mould.

In the middle Table Head Formation, 130 feet above the base at the type section, at Table Cove and the isolated limestone, occurs a type of hypostome (Pl. 66, figs. 5-8) which may belong to this species. The middle body is oval in outline, moderately convex, with prominent maculae and the posterior part of the middle body small and crescentic. The narrow lateral borders are separated from the middle body by a deep furrow, the posterior border is wide and bears a short, blunt median spine.

Striking is the large, quadrangular anterior wing, directed upward and outward, impressed by a fold along the outer margin. External surface is finely granulate, in a similiar manner to the external surface of *M. mira.* The size and occurrence of this hypostome is consistent with it belonging to this species, but the middle body does not display the median anterior bulge so characteristic of some encrinurid hypostomes (Lindström, 1901, pl. 4, fig. 5; Cooper, 1953, pl. 13, fig. 12). On the other hand, the hypostome attributed to *Cybele bellatula* (Lindström, 1901, pl. 4, fig. 2) apparently also lacked this bulge and possessed large anterior wings.

Discussion. Billings recorded this species from boulders from the shore north of the mouth of Portland Creek. In the present investigation a single pygidium was obtained from boulders at the same locality (Whittington and Kindle, 1963, p. 753). Raymond refers to "a rather poorly preserved thorax" obtained from the lower Table Head Formation on the west side of Gargamelle Cove (Schuchert and Dunbar, 1934, p. 25, fig. 4), but this specimen (MCZ 7568) appears to be that of the thorax of *Ectenonotus westoni* (Billings, 1865). This species is characteristic of the lower Table Head Formation, whereas *M. mira* has only been found in the middle Table Head Formation. A second species of *Miracybele* is present in basal calcarenites of the Antelope Valley Limestone, Nevada (Whittington *in* Kay, 1962, p. 1424, table 2). The fragment of a cranidium figured by Nikolaisen (1961, p. 295, pl. 2, fig. 4) as *Pliomerops* sp. has the glabellar shape and lobation, possible median furrow of the frontal glabellar lobe, and cheek with the eye ridge running far outward and backward, that make it appear quite probable that this specimen represents a third species of *Miracybele.* It is from the Ogygiocaris Shale (4aα) of the Oslo region, and is of approximately the same age as the Newfoundland species. Species of *Miracybele,* though rare, thus appear to be widespread.

Encrinurid gen. et sp. ind.

Plate 68, figures 6-8, 10, 11

Discussion. Two specimens indicate the presence of at least one additional encrinurid species in the middle Table Head Formation. The fragment of a glabella is quite strongly convex, the three lateral furrows directed inward and slightly backward, deepest at the inner end, the median glabellar lobe much wider (tr.) than the lateral lobes. Scattered tubercles, including a prominent pair in line with lateral lobes 3p, are present on the external surface.

The internal mould of the pygidium is unlike that of *Miracybele* in both outline and convexity. The median smooth band of the axis extends back from the broken region of the first three or four rings, and there are up to sixteen rings indicated on this axis. On the pleural regions four narrow, raised bands represent the posterior pleural bands of four segments, the intervening region smooth and much broader than the bands. The fourth pair runs back and slightly inward behind the tip of the axis. Scattered tubercles are present on the raised bands, which are extended beyond the margin as short spines. This type of pygidium has not only been found 265 feet above the base of the type section, but in Table Cove and the isolated limestone.

Family DALMANITIDAE Vogdes, 1890

Genus CALYPTAULAX Cooper, 1930

CALYPTAULAX INCEPTA n. sp.

Plate 67, figures 1-4, 6

''*Calyptaulax*'' sp., Whittington and Kindle, 1963, text-fig. 2.

Holotype. GSC 18368, incomplete and exfoliated cranidium, from 350 feet above base of unit 8, lower Table Head Formation.

Other material. Two fragments of external moulds of the pygidium, from 379 feet above base of unit 8, lower Table Head Formation; cranidia and pygidia from Portland Creek.

Description. Cephalon subsemicircular in outline, convex, the posterior part of the large eye lobe the highest point. Glabella expands forward from occipital ring to maximum width across frontal lobe (which is twice that of occipital ring), the length (sag.) slightly greater than the maximum width. Course of axial furrow sinuous; in front of outer end of lateral glabellar furrow 3p the axial furrow dies out, and anterior margin of glabella is outlined only by a slight change in slope, this change in slope being followed by the anterior branch of the facial suture. Occipital ring convex, the posterior margin the highest point of the glabella, widest behind the median lobe, narrowing and slightly inflated distally. Occipital furrow shallow medially, becoming deep distally between the outer part of the ring and lateral lobe 1p. Lateral glabellar furrow 1p commences at axial furrow and runs a short distance straight inward, then bifurcates, one shallow branch running directly back and not quite reaching the occipital furrow, so that it outlines the slightly inflated, subtriangular basal glabellar lobe. The anterior branch of lateral furrow 1p runs inward and forward for a short distance and dies out, outlining the curved posterior margin of lateral lobe 2p. Lateral furrow 2p is directed inward and slightly forward, commencing at the axial furrow and deepening inward; lateral lobe 2p is quadrangular in outline. Lateral furrow 3p commences at the axial furrow and runs inward and backward, so that lateral lobe 3p is subtriangular in outline. The outer end of lateral furrow 1p is situated midway between the outer end of the occipital furrow and lateral furrow 2p; a much greater distance separates the outer ends of lateral furrows 2p and 3p. Inner ends of lateral furrows 2p and 3p, and of the anterior branch of furrow 1p, lie in the same exsagittal line, and width (tr.) of median lobe is approximately the same as that of lobe 3p. Median lobe is inflated adjacent to the occipital ring, so that it forms a low ring between lateral lobes 1p; anteriorly the median lobe merges with the diamond-shaped frontal lobe. The narrow (sag. exs.) preglabellar area in front of the fused branches of the facial suture has a similar slope to the slope of the frontal glabellar lobe, there is no preglabellar furrow, and at the margin the exoskeleton is flexed sharply to slope downward and backward as the gently convex doublure (Pl. 67, fig. 6). This anterior part of the doublure extends in beneath the frontal glabellar lobe, and at the inner margin is flexed ventrally. Convex, triangular cheek dominated by the prominent eye lobe, which extends from a point adjacent to the outer end of lateral glabellar furrow 3p to the posterior border furrow. The palpebral lobe is formed by a prominent, gently convex band curved in a semicircle, the palpebral furrow deep and broad. The eye surface slopes steeply to the furrow which marks the outer margin of the eye lobe, and the convex facets are arranged in diagonal lines. Inside the curved palpebral furrow the fixed cheek is gently inflated, and the narrow posterior portion separating the eye lobe and axial furrow slopes steeply to the border furrow. Behind the eye lobe the posterior border is narrow and convex; distally it becomes flattened. The genal angle is rounded, and the cheek outside the eye lobe slopes steeply. Lateral border furrow broad and shallow, curving round in front of the eye lobe to merge with the axial furrow; posterolaterally the border furrow deepens and at the genal angle curves to merge with the posterior border furrow. The lateral border is relatively broad and gently convex, the exoskeleton at the margin sharply flexed so that posterolaterally the doublure lies immediately beneath the dorsal exoskeleton, as it does beneath the posterior border. The form of the anterolateral part of the doublure is not known, and hence it is uncertain whether or not a vincular furrow is present. Posterior branch of facial suture curves around behind eye lobe immediately outside the bounding furrow, then curves forward and outward across cheek to margin, reaching this margin approximately in line with lateral glabellar furrow 1p. Only a fragment of the exoskeleton is adhering to the left cheek, which shows a fine granulation on the lateral border. Elsewhere the internal mould shows the low, closely-spaced tubercles on the glabella and fixed cheek, and the shallow pits in the cheek outside the eye lobe.

The triangular pygidium is convex, the axis divided by seven ring furrows which become progressively fainter posteriorly. These furrows run transversely in the medial portion, the outer portion being a curve gently convex forward. Seven deep pleural furrows traverse the pleural regions, and on the outer part of these regions the shallower interpleural furrows are visible, running diagonally to the pleural furrows.

Discussion. In 1954 (p. 135) I attempted to distinguish between *Calyptaulax* and *Calliops* Delo, 1935, emphasizing particularly that in the latter genus the second glabellar furrow was distinct and deep throughout its length, and implying that it extended to the axial furrow. This is in contrast to the condition in the type species of *Calyptaulax, C. glabella* Cooper, 1930 (pp. 388-389, pl. 5, figs. 9-11), in which this furrow does not reach the axial furrow and lateral glabellar lobes 2p and 3p are partially fused. This single criterion is not easy to use, particularly as the definition of the lateral glabellar furrow (as Cooper recognized) is different on the external surface and internal mould. Both Delo (1940, pp. 94-95, pl. 11, fig. 1) and B. N. Cooper (1953, p.33, pl. 16, fig. 12) based their understanding of *Calliops callicephalus*, the type species, on material which came from the Trenton Group at Trenton Falls, New York State. However, Hall's (1847, p. 247, pl. 65, figs. 3a-i) original material did not come from this locality, but from fourteen miles to the southeast, near Middleville, Herkimer County, New York State. The exact horizon from which the material came is uncertain, and the type specimens have not been traced. In these circumstances it seems best not to use the name *Calliops.* Thus the present species is referred to *Calyptaulax,* and I include in this genus many of the species referred by Delo (1940) and B. N. Cooper (1953) to *Calliops.* The suprageneric classification of trilobites of this type is uncertain but, as discussed previously (Whittington, 1962, p. 12), I incline to place *Calyptaulax* in the Dalmanitidae.

The new species from the lower Table Head Formation is the oldest known of the *Calyptaulax*—*''Calliops''* type. Slightly younger is a species from the Lenoir Formation (as restricted by Cooper and Cooper, *in* Cooper, 1956, p. 72, and referred to the Marmor Stage) — *gracilens* Raymond, 1925 (pp. 162-163, pl. 10, fig. 18; Cooper, 1953, p. 34, pl. 15, figs. 4-7, 15). Raymond described only the pygidium of *C. gracilens,* but Cooper figured the glabella in which lateral lobes 2p and 3p appear to be the same relative size and shape as those of the Table Head species. *C. annulatus* (Raymond, 1905), from the Chazyan of New York, is of approximately the same age as *C. gracilens.* Judging from the cranidia illustrated by Delo (1940, pl. 11, figs. 5, 6) the cephalon is different from that of *C. incepta* n. sp. in that lateral glabellar lobe 1p is considerably smaller, the frontal lobe relatively larger, and the curvature of the palpebral rim apparently different. From younger beds of the Porterfield Stage many species have been described, one of which is *C. angusta* (B. N. Cooper, 1953, pp. 35-36, pl. 14, figs. 1-6; B. N. Cooper gave the horizon as ''Upper Lenoir'' limestone, now the Arline Formation of Cooper and Cooper *in* G. A. Cooper, 1956, pp. 41-43). Particularly the holotype cephalon of *C. angusta* is like that of *C. incepta* n. sp., showing lateral glabellar lobes of similar relative size and shape, the eye lobe of the same size, a difference being that lateral lobe 1p appears to be less isolated. Quite different from *C. incepta* n. sp. are the species from the Edinburg Limestone of Virginia described by Cooper (1953, pls. 17, 18), notably in the direction of the glabellar furrows and consequent shape of the lobes, and particularly in possessing the small, subcircular basal lobes. Still more divergent is a contemporaneous species *C. holstonensis* (Raymond, 1925, pp. 161-162, pl. 10, figs. 9-11; Cooper, 1953, p. 41, pl. 15, figs. 16-18, not figs. 13, 14) in which lateral glabellar furrow 2p does not reach the axial furrow, lateral furrow 3p is sigmoidally curved, and the palpebral lobe is much less strongly curved.

The new species from the lower Table Head Formation thus appears to be the first known representative of an evolving plexus in middle and upper Ordovician rocks in North America. However, until better material of many species is more clearly described, it will not be possible to discern phylogeny and relationships.

Family uncertain

Cranidium gen. ind. 1

Plate 19, figures 13, 14, 18

Material. A single incomplete cranidium from 90 feet above the base of the middle Table Head Formation, type section.

Description. Glabella of maximum width at posterior edge of basal lateral lobes, this width only slightly less than the length (sag.), convex so that anterior part of the glabella overhangs preglabellar furrow. Posterior margin of occipital ring strongly curved, occipital furrow behind median glabellar lobe straight; transverse, distal part of furrow runs in curve which is convex backward behind the basal glabellar lobe, at the extremity curving forward and dying out without reaching the margin of the basal lobe. In lateral view (Pl. 19, fig. 18) the distal tip of the forwardly-curving occipital ring is seen to merge into the outermost posterior part of the basal glabellar lobe. This latter lobe defined by lateral furrow which commences at about half the length, runs inward and backward, curves and becomes shallower and runs directly back to the occipital furrow. The elongate-oval basal lobe is moderately inflated and set off from the remainder of the glabella. Lateral glabellar furrow 2p represented by a faint depression adjacent to the axial furrow, and situated a short distance in front of 1p. Median glabellar lobe rises steeply in front of occipital furrow to form a low hump; in front of this hump it slopes forward and merges with the frontal lobe. Glabella outlined by axial and preglabellar furrows which are distinct and continuous in front of lateral furrow 1p and around frontal lobe; beside basal glabellar lobe and occipital ring, axial furrow is shallow. Little of the fixed cheek is preserved, except the anterior part beside the axial furrow which forms a continuous band with the gently convex preglabellar field. The outer margin of this band appears to be formed by the anterior branches of the suture as they run forward and curve around toward the midline. The posterior border is also preserved, narrow, gently convex, directed outward and slightly backward. External surface except in furrows covered with faint lines arranged in Bertillon pattern, on glabella running roughly concentrically. Low tubercles are scattered on the glabella and occipital ring, and are best seen on the preglabellar field.

Because so little of the cheek is preserved, the affinities of this form are problematical.

Cranidium gen. ind. 2

Plate 68, figures 1-3

Material. GSC 18377, incomplete glabella from middle Table Head Formation, isolated limestone.

Description. Glabella trapezoidal in outline, the straight sides diverging forward so that the maximum width is across the anterior lobe and slightly greater than that across the occipital ring; moderately convex transversely, more strongly convex longitudinally so that the frontal lobe overhangs preglabellar furrow. Occipital ring wide (sag. and exs.) behind median lobe, narrowing behind basal glabellar lobe, median part forming highest part of cephalon. Occipital furrow narrow and deep, median lobe rising as steeply from it as does the occipital ring. Three pairs of lateral glabellar furrows, lateral furrow 1p directed inward and backward, straight, reaching the occipital furrow and cutting off a small, triangular basal glabellar lobe which is gently convex. Lateral furrows 2p and 3p much fainter, directed straight inward for a short distance before dying out, situated at an equal distance from each other, furrow 1p, and the preglabellar furrow. Lateral furrow 2p appears slightly fainter and shorter than 3p. Frontal glabellar lobe with straight margin medially, anterolateral corner rounded; preglabellar furrow continuous with axial furrows and moderately deep. Fixed cheek and preglabellar area (if present) not preserved. The specimen appears to be an internal mould, and suggests that the external surface is either smooth or finely granulate.

Discussion. The affinities of this glabella are uncertain — the small basal glabellar lobes combined with the forward expansion do not suggest, for example, a cheirurid. There is some resemblance to the catillicephalid glabella, for example, that of *Theodenisia* (Rasetti, 1954, pp. 607-609, fig. 3). In this genus the glabella is typically forwardly expanding, straight sided, with three pairs of lateral glabellar furrows. However, the basal glabellar lobe of the present example is much smaller than that in species of *Theodenisia.* A relationship of the Table Head cranidium to members of this late Cambrian genus is possible, but so far as I am aware intermediate forms in the Lower Ordovician are unknown.

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